A Mariculture Assessment of Apalachicola Bay, Florida

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I. EXECUTIVE SUMMARY

Mariculture is marine or salt water aquaculture. Florida law defines aquaculture as the cultivation of animals and plant life in a water environment. Aquaculture may be undertaken to produce food for human consumption, bait and stockers for recreational fishing, ornamentals for the aquarium hobbiest, juveniles for enhancing natural fisheries, and raw materials for energy and biochemicals.

Natural fisheries stocks are finite and are rapidly nearing their maximum sustainable yields. Demand for seafood is increasing and approximately 50% of the seafood Americans eat is imported, creating an annual trade deficit exceeding two billion dollars. Development of a mariculture industry could supplement and ease the pressure on existing fisheries, to help meet the growing demand, by producing quality products available year round and consistent in texture, flavor and size. Mariculture could provide juveniles to enhance both commercial and recreational fisheries and create new economic opportunities compatible with existing coastal uses and lifestyles.

Apalachicola Bay is an important and pristine estuary which has received a considerable amount of protection by law. The economic base of Franklin County has always been dependent on the productivity of the river and bay, and the commercial and recreational fisheries it produces which in turn are reflected in the traditions and lifestyles of the people residing in the county. However, the fisheries resource, especially oysters, have been experiencing increased pressure resulting in a declining fishery over the past few years. The decline has been due to a combination of factors including overfishing, inadequate enforcement of laws, social conflict and policies of multiple users, environmental stresses from sewage, non-point sources, urban development, upstream users, and man-made bay alterations, and natural mortality. The net results are an unstable economy and a poorly managed resource. The solution is to improve resource management through a cooperative effort combining biological information, economic analysis, education and sociological change. Mariculture could be one component of the solution, applied as a management technique, to enhance the long-term productivity of the fisheries resource.

Many criteria need to be considered and thoroughly evaluated prior to selecting an aquaculture species and entering an aquaculture enterprise. Suitable sites, appropriate culture system, culture techniques, and cost of production must be studied and feasibility assessed. A business plan must be developed detailing required capital, identifying markets and competitors, and assessing risks which will impact the venture's potential of earning a profit.

Mariculture systems suitable for Franklin County include: Upland ponds sited along the north shore of St. Vincent Sound; cage and net-pen culture in semi-sheltered areas of the bay; off bottom shellfish culture; and stock enhancement techniques such as the construction of artificial oyster reefs and hatchery reared juveniles for release into recreational and commercial fisheries. Low winter temperatures will limit the culture of some species in the bay, while rapidly fluctuating salinities will limit others. Overall, Apalachicola Bay has tremendous mariculture potential. The oyster is the species with the greatest and most immediate potential and a full assessment of oyster problems, possible solutions, culture systems, and management techniques are provided in this report. Bait shrimp, bait fish, food shrimp, hybrid bass, redfish and sturgeon are recommended as having significant mariculture potential. Eels, grouper and pompano may also hold some future promise. Small scale demonstrations and economic evaluations are needed for each of these species prior to large scale commercial development. The research and education program of the Estuarine Sanctuary is recommended as the vehicle to evaluate these species as well as off bottom oyster culture systems.

Constraints to mariculture development are primarily social and administrative rather than biotechnical. Local sentiments are very traditional and in the past have greatly resisted any change or innovation. Government has a poor understanding of mariculture and has generally lumped this new emerging technology into regulatory categories intended for commercial or recreational fishing. A complete review of all pertinent laws should be carefully undertaken to resolve problems due to cross referencing, jurisdictional overlap and the use of ambiguous terminology in order to clearly define aquaculture in regulations, reduce uncertainty, and clarify authority. Mariculture is coastal dependent requiring good quality water and access to marine sites. Mariculture should be designated as an appropriate and priority use of the coastal zone in coastal management programs. Franklin County should define mariculture as agriculture for the purpose of zoning codes and encourage its development by requesting modification of the leasing procedures for the water column and bay bottoms.

Apalachicola Bay is a multi-use system where many of the uses have a tendency to come into conflict with one another. Fisheries user groups often compete with one another on obtaining priority fishing rights. Crabbers, bay shrimpers, oystermen, and finfish seiners have often engaged in conflict over the use of the resource. Competition between commercial and recreational fishermen is growing and will intensify as the resource continues a downward trend. The economic importance of recreational fishing dwarfs commercial fishing statewide and its growth in Apalachicola Bay should be seriously considered in conflict resolution. Property owners and the aesthetics they demand and commercial navigation are other users who must also have space allocated in long range planning solutions.

The oyster population in Apalachicola Bay is very fecund with few pests and diseases. The present problem is overfishing as the resource is in danger of being picked clean. The number of oystermen has more than doubled in the past ten years resulting in more people spending more time looking for the same amount of oysters. The intense competition among oystermen adds to resource depletion as conservation practices are ignored and just about anything is tonged off a bar and sold. The problem came to a head in the spring of 1984 when the bay was closed for nearly a month and the local economy experienced difficulties.

The biological solution is to cultivate more oysters and manage the resource wisely. The majority of oysters shucked in Apalachicola are trucked in from Texas and Louisiana where they are primarily grown on leased beds. Apalachicola Bay is presently producing about 5 million pounds of shucked oyster meats each year. Proper cultivation techniques employed in the bay could raise production to well over 150 million lbs of shucked oyster meats per year. Oyster production seems primarily limited by the aspirations of industry members and natural mortalities.

The construction of thousands of acres of artificial oyster reefs over a period of time will enhance the entire fisheries resources of the estuary, if developed and managed properly. Reef construction methodology needs refinement over current practices to develop the most economical reef with the best long-term production. A properly constructed oyster reef will continue to produce over decades for a one-time investment. Proper management of the reef may include only harvesting the large oysters, culling, relaying and seeding with coon oysters, and maintenance cultching with clean bleached shell. A research program demonstrating new and existing reef construction methods and monitoring environmental factors correlated with community settlement, succession, and climax, could be a long-term objective of the Estuarine Sanctuary.

Reopening the bay to leases should be given serious consideration. Oyster leases have provided many benefits in states which have lease programs and these programs should be assessed and their feasibility for applicability in Apalachicola Bay determined. Water column leases would allow added benefits of off bottom oyster culture and diversification into the culture of additional organisms. Leases could relieve pressure on the public bars, supplement, extend and create new markets which could be serviced year around, produce a higher quality product, increase yield per unit of production acreage, and provide year around employment.

Government assistance would be necessary in initially planning, implementing, and managing a lease program. Individual or family leases could be developed on ten-acre tracts for a minimum $65,000 investment broken down into a fixed and variable operating cost budget approximating $15,000 per year, but having the potential of returning $30-60,000 per year under good management conditions. Low cost government loans with deferred interest could assist in implementing such a program. The state should additionally provide a full-time oyster expert to reside in Franklin County and act as an extension agent to assist in lease and reef development, provide production and harvesting information, and act as an advocate for the oyster industry with government.

Any lease program in Apalachicola Bay would have to be equitable in design to insure the preservation of the independent oystermen, protect new and existing public bars, and prevent monopolies. A coalition, coordinated through the Estuarine Sanctuary, of Seafood Workers Association members, each representing a different segment of their industry (i.e., Oyster Dealers Association members, commercial fishermen, recreational fishermen, other county residents, the Marine Patrol, and government agencies) should be organized to eliminate illegal activities presently harming the resource and develop a long-term comprehensive plan to manage and enhance the resource. Leadership and cooperation by industry members in developing and managing <u>their</u> resource is the key to the success of any program considered for Franklin County. State agency persons would become a resource to work under the direction of this citizen group.

The formation of a cooperative would give local industry members a strong voice in the development and protection of their resource. The cooperative could literally develop thousands of acres of naked bay bottom into productive, well-managed reefs, to guarantee members a share of the resource. Additional facilities for processing, depurating, fattening, live storage, and the development of improved strains or new organisms for culture, including a multi-species hatchery, could be implemented by the co-op over time to diversify and expand the seafood based economy of the area.

Mariculture requires a reliable source of good quality water which parallels one of the desired environmental goals for the entire Apalachicola River and Bay system. In fact, mariculture cannot develop to any great extent unless the long-term integrity of the system is insured. Point and non-point sources, as well as upstream sources, must be abated and the basin maintained as much as practical in its natural state. A good deal of the land in and around the bay and along the river floodplain is already in public ownership. The remainder should be protected and the system permanently set aside as a nursery and aquatic food producing area of vital importance to the public interest.

As Florida's population grows, more and more pressure will be exerted on our marine resources for food and recreation. Recognizing this reality, we should forever set aside the Apalachicola River and Bay system for use as a nursery for marine organisms and develop its aquatic resources, through artificial techniques, to satisfy our long-term seafood and recreation needs.

II. INTRODUCTION

A. Overview of the Study Area

Apalachicola Bay is considered to be one of the most important estuarine systems in the state. Much of the system remains largely undeveloped in a pristine state enhancing the high productivity of the estuary. The bay is a wide, shallow estuary located behind a line of barrier islands and is approximately 36 miles long, from 1-14 miles in width with an average depth of 5 feet for a total area close to 180 square miles. The Apalachicola-Chattahoochee-Flint (ACF) River system drains portions of Alabama, Georgia and Florida into the bay. The Apalachicola is the largest river in Florida in terms of flow and is the primary force driving the complex estuarine system. Excellent backgrounds of the river and bay system can be found in Livingston (1983), Florida Department of Environmental Regulation (1984), and Brady, Leitman and Edmisten (1984). Although the estuary is divided into six sections based on natural bathymetry and man-made alterations, this study only encompasses three sections: East Bay, St. Vincent Sound, and Apalachicola Bay (Figure 1). All of this area is included in the Apalachicola National Estuarine Sanctuary (ANES) which both recognizes and protects the excellent water quality found in the system.

Numerous technical studies of the bay system have been undertaken over the years with many of the results applied to various planning and management efforts. The economic base of the bay has always been dependent on the productivity of the river and

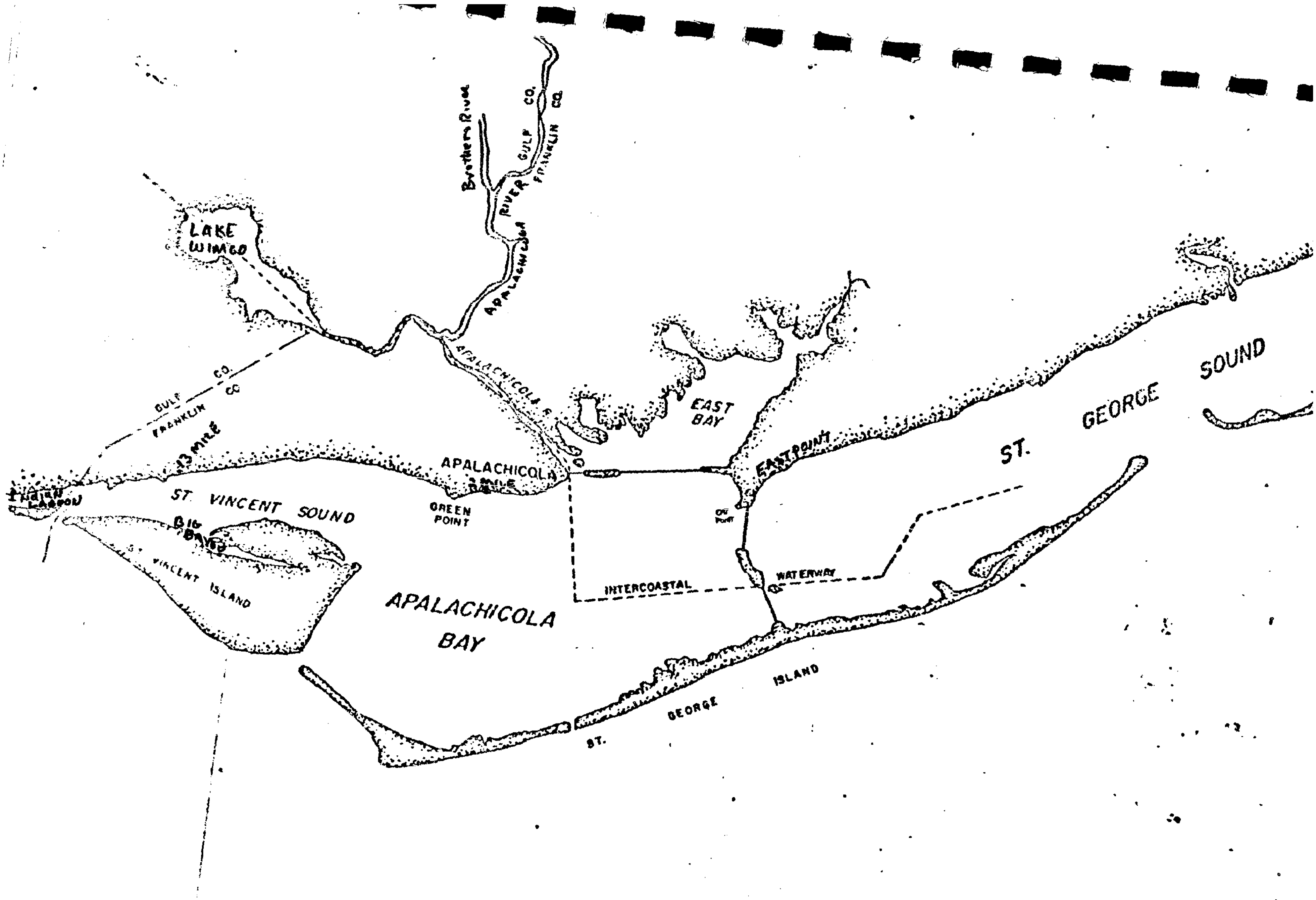

Figure 1
STUDY AREA

bay, and the recreational and commercial fisheries it produces. Many planning efforts have focused attention on fisheries and the protection of the natural resource base which supports those fisheries. However, protecting habitat and the integrity of the system alone will not guarantee long-term survival of the fisheries resource. New approaches to managing and protecting these resources are needed in what now has become a multiple-use area where many of the uses are in competition. Mariculture may be one such management technique to enhance long-term fishery productivity and one such compatible use component of a well managed resource in this coastal zone.

The bay, in addition to recreational fisheries, supports major commercial fisheries for oysters, shrimp, crabs and finfish. The problems in the bay's fisheries are evident from the declining production trends. More than half the local residents make a living from fishing and the seafood industry contributes over $15 million a year to the local economy. Since the turn of the century, oyster acreage in the bay has declined from 12,000 to 6,000 acres due to habitat loss. Overfishing and poor management are seriously threatening the future of the oyster fishery. Shrimp have been the most valuable fishery to the area and the importance of the estuary as a nursery grounds is reflected in total shrimp landings (Table 1) both in and outside of the bay. However, a major characteristic of any aquatic species is widely fluctuating abundance and inconsistant supply which may depress commercial value in any given year. A commercial fishery may, therefore, collapse or seriously decline at any time due to fishing pressure, pollution, development, or natural biological processes. The importance of fisheries is reflected in the traditions and lifestyles of the people residing in the county. But this economy is in need of new endeavors which complement the traditional way of life while not adversely impacting the integrity of the resource. The development of mariculture offers new opportunities in local economic development and is compatible with the economy and lifestyle of the entire county. In addition, mariculture used as a tool, fits the goals and objectives of the Estuarine Sanctuary in guiding compatible development while maintaining the natural resources.

B. Scope of the Project

This project assesses the mariculture potential of Apalachicola Bay and attempts to relate that potential as a management tool to assist in solving fisheries problems faced by the system. This report describes mariculture techniques suitable to the bay, examines the mariculture potential of a number of candidate species, and selects one species for detailed discussion and development. Regulatory problems, conflicts between user groups, and economic considerations regarding mariculture are discussed. The report may be used to develop an R&D or demonstration project on a potential mariculture candidate, as an information source for writing a business plan for development of a commercial mariculture venture, or as a tool to be used by government agencies to implement mariculture into the planning and regulatory mechanisms.

III. MARICULTURE OPPORTUNITIES

A. Definition

Aquaculture is defined as the controlled cultivation and harvest of aquatic plants and animals (National Aquaculture Development Plan, NADP, 1983). Florida law defines aquaculture as the cultivation of animals and plant life in a water environment (Chap. 253.67(1) F.S.). Both definitions imply the organism(s) are grown in an aquatic medium, the natural habitat of the organism(s) is water, and some part or all of the life cycle or culture period is influenced or manipulated by man. The degree to which the life cycle and environmental needs of an organism are controlled by the culturist may range from simply relaying coon oysters for growout on a lease site to artifically maintaining a fish from egg to harvest size in a tank. Aquaculture may be undertaken to produce food for human consumption, bait and stockers for recreational fishing, ornamentals for the aquarium hobbiest, juveniles for enhancing natural fisheries, and raw materials for energy and biochemicals. Mariculture refers to aquaculture carried out in a marine or saltwater environment. Aquaculture is the more encompassing term. Both mariculture and aquaculture will be used interchangeably in this report.

B. Potential for Mariculture Development

The potential for aquaculture development in Florida is tremendous. Aquaculture can provide new opportunities in the areas of economic growth, employment and agriculture. Presently half the seafood Americans consume is imported. The trade deficit in fish and fisheries products has increased 100% since 1976 and is currently valued at over $2 billion each year. This represents 10% of the annual trade deficit and is second only to petroleum. Wild stocks of aquatic organisms are finite and can no longer supply man with all the food he demands from our fresh and salt water resources. These resources are already stressed and are predicted to reach their maximum sustainable yield by the year 2000. While production of the world's fisheries has remained roughly the same, demand for these products has continued to increase. Aquaculture can fill some of this gap and continue to expand while fisheries near their biological limits. Thus, while aquaculture cannot replace the traditional capture fisheries, it can act to supplement and expand fisheries supply.

Production of food through aquaculture could increase the yields of fish and shellfish, help meet the demand for fresh seafoods, produce a high quality product consistant in flavor, texture and size, stabilize the supply of certain species to supply a year round market, help to stabilize commercial prices, and bring new revenues to the State. For example, cultured oysters typically have a more regularly shaped shell, making them easier to shuck, bring a higher price, and are available year-round. Due to the higher land and labor costs found in Florida, species selected for culture will most likely be those with a high market value. A good fish meal at a Florida restaurant is a high priority among tourists, as is the opportunity to do some recreational fishing. As the population in Florida continues to grow, more pressure will be placed on the environment to produce food and provide recreation. Aquaculture can help ease this pressure by supplementing commercial fisheries and providing juveniles for enhancing both recreational and commercial fisheries. Aquaculture is compatible with environmental goals as both require clean water. Beside food, aquaculture to produce marine biochemicals from plants, animals and microorganisms as sources of medically, agriculturally, and industrially useful chemicals is an untapped resource (Attaway, 1983). Development of an aquaculture industry will also have a favorable economic impact in the areas of construction, equipment, feeds, processing, shipping, training and research.

The mariculture potential for Franklin County is excellent. The Apalachicola Bay system receives the maximum amount of protection currently allowed by law. This system is a Class II water, an Outstanding Florida Water (OFW) along with the Apalachicola River, an Aquatic Preserve, and a National Estuarine Sanctuary. These recognitions act to protect the high water quality of the bay system and the fisheries it supports. Mariculture can offer new economic and employment opportunities for this coastal community by diversifying the fisheries based economy. Mariculture is compatible with the existing lifestyles and the community has expressed strong interest in maintaining the fisheries related economic base. Mariculture ventures will require similar skills already possessed by area residents. These ventures will require labor, and support businesses such as suppliers of equipment or feed and processing and marketing of cultured products. Labor, processing and market channels are already available in the community. Oysters have the most immediate mariculture potential. Increased production of oysters could employ more oystermen, increase the harvest per person, and supply more product to an already strong market. Prochaska and Mulkey (in Andree, 1983) have shown that Franklin County oysters are primarily exported triggering a chain reaction throughout the local economy. Oysters account for nearly one half the total economic multiplier impact in the county. Producing bait and stockers for the recreational industry also has good short and long-term potential. Recreational fisheries will continue to grow in terms of both gross dollar value and political decisions concerning fisheries. Stock enhancement of the natural fishery has long-term potential to help commercial fishermen. Finally, mariculture can ease developmental pressure around the bay and make more efficient use of the areas resources with minimal impact on the environment. This last point is very important in considering the large economic impact and resultant degradation of the bay from extensive development of St. George Island. Mariculture can contribute towards counteracting the developmental economic argument by demonstrating the abundance of dollars which may be produced in the bay.

C. Problems Constraining Mariculture Development

Florida has abundant water resources, a favorable climate, a long coastline, a number of resource persons with technical expertise, and existing markets to encourage the development of mariculture. However, Florida, like many other states, has numerous constraints on the development of an aquaculture industry. These general constraints are summarized as follows:

(1) Government: mostly political and administrative; legal and regulatory; jurisdictional overlap and inadequate coordination; poor understanding of aquaculture;

(2) Competition for land and water;

(3) Multiple use conflicts;

(4) Financial risk; locating venture capital; uncertainty of profits;

(5) Education and information transfer; and

(6) Biotechnical constraints: use of wild animals for broodstock; poor understanding of nutrition and diets; preventing and control of disease; and poor knowledge of water quality factors in culture systems.

Many of these constraints can be solved through research and development. Planning and conflict resolution should ease others. However, strong suppoert by government will eliminate institutional constraints and reduce financial risk, thereby making aquaculture more attractive to entrepreneures.

IV. MARICULTURE SYSTEMS

A. Ponds

The culture of aquatic organisms can occur in a variety of structures and enclosures; however, the most common, oldest, and versatile culture unit remains the pond. Ponds can be constructed in different sizes or with special features to fit a specific culture operation. Design and layout of a pond or pond system will determine its management flexibility. Ponds used for mariculture must be constructed in the coastal zone to be sufficiently close to a salt or brackish water supply. Since competition for coastal land is very keen resulting in high land values, expansion of mariculture into the coastal zone will depend upon the ability to design ponds for areas unsuitable for other uses such as homes, condominiums, commercial buildings, or silviculture. However, due to an already overabused coastal zone, many of these unsuitable areas may now be considered environmentally sensitive and protected by laws such as the Wetlands Act. Access to these lands may present an insurmountable barrier to the development of mariculture. The barrier might be broken by authorizing mariculture as a designated use of the coastal zone and incorporating mariculture siting into the local coastal zone planning process. This section will discuss the general principles of pond design and construction. Specific areas for locating ponds in and around Apalachicola Bay are discussed in the section on siting.

Preliminary considerations in locating a pond include topography, water supply and soil quality. Soil should have good water retention capabilities. Soil analysis as well as pond design assistance is a service of the local District Conservationist of the Soil Conservation Service (SCS, USDA). Soil samples at a prospective site should be analized for clay, sand and humus content. Ideally clay content should be greater than 20% and seepage or water loss should be less than 10 cm. from a 15 cm. diameter hole in 24 hours. Highly permeable soils may sometimes be sealed using a number of methods ranging from compaction to hauling in clay or bentonite to the use of chemical sealers and pond liners. Soil quality should be free of pesticide residues to avoid killing or contamination of organisms under culture, and have a certain amount of fertility to support healthy plankton populations. Soils with a shallow underlying water table may be suitable pond sites even if clay content is low as water will still be retained. Much of the land in the lower Apalachicola River Basin sits over shallow water tables.

Ideal topography for ponds is on lands which are nearly flat. Ponds should not be irregular in shape or have a bottom contour which act to reduce harvest efficiency. Pond bottoms should be sloped to facilitate drainage with a minimum horizontal to vertical ratio of 1000:1. Higher slope ratios may be preferable depending on the size of the pond and the organism to be cultured. A cardinal rule of all pond construction is a pond should be drainable. The pond should also be free from flooding, be accessible year round, and be reasonably close to markets. A pond should be able to be drained individually and drained completely dry. Drainpipes should be large enough (6-10" depending on pond size) to allow rapid drainage in 48 hours or less. Stand pipes are routinely used as drains, as both water level and drainage are controlled by rotating the pipe about a coupling located on the bottom of the pond. A harvest basin is recommended for most production ponds as the cultured organisms are caught in the basin as the pond drains and are subsequently easier to harvest. A harvest basin is usually 12-18 inches deeper than the rest of the pond and occupies a maximum area no more than 10% of the total pond area. Harvest basins are often referred to as a pond within a pond.

The two general types of ponds constructed are dugout and levee ponds. Dugout ponds are excavated with the bottom laying below the ground surface. Levee ponds are excavated a few feet down and the removed soil is used to build a dam or levee completely around the pond so that the water level is above existing ground level. Levee ponds are preferable in Franklin County as they can be completely and easily drained. Levees should be of sufficient size to withstand the pressure of the water in the pond. Their bases should be constructed of non-porous material and free of roots and other obstructions so as to form a water tight bond. Pond slopes are usually 3:1 or 4:1. Levees should be grassed on the top and outside after construction to prevent erosion. Shape of ponds are usually rectangular, but a square pond requires less footage of levee to achieve the same water surface area. All ponds should have the same width in order to use the same net for harvesting.

The size of a pond is influenced by a number of factors including available labor, topography, capital and construction costs, market demand, management or production schedules, and most importantly the organism to be cultured. Small ponds less than an acre in size are normally used for culturing fry and fingerlings while larger ponds are used for growout or to hold broodstock. Small ponds are easier and quicker to harvest, easier to treat for disease, can be drained and filled quickly, and less subject to levee erosion by wind. Large ponds are less costly to construct per acre of water, require less space per acre of water, and less susceptible to oxygen depletion due to more wind action. In fact, large ponds should be laid out with the long axis parallel to prevailing winds for improved mixing and aeration from the wind. Depth of ponds may depend on the organism to be cultured, but in general, are four to six feet for fish culture and one and a half to three feet for shellfish culture.

Water supply should be constant, of high quality, and available throughout the year. Consideration should be given to maximum evaporation rates for the area, when oxygen problems could become most critical and water exchange necessary. A general approximation of 200 gal/min/acre may be used to estimate water quantity. Bay water is the choice for ponds constructed in the study area. Since tides are not sufficient in the Northern Gulf to use weirs or monks, bay water will have to be pumped into ponds. The pump should be sized to provide the flow rate necessary to service all ponds at maximum head. Intake pipes should be 6 to 8 inches in diameter and have a backup pump in case of emergency. Valves should have a long life and be resistant to corrosion. PVC valves are often used for saltwater ponds. Water inlet pipes should be positioned at the catch basin and drainage end of the pond. Intake lines should be slightly larger than estimated as screening materials will be required to filter out unwanted organisms. Socks made of Saran or tubular nylon webbing are usually secured over the inlet pipe with a stainless steel hose clamp and may be effective for 2-5 months. Periodically the sock should be removed and washed.

One drawback of this type of mariculture pond is that the salinity of the pond is controlled by the salinity of the bay. Abrupt changes in salinity can cause stress, reduce feeding and possibly result in mortalities. Species with narrow salinity tolerances would be difficult to culture. Management becomes crucial so that periods of greatest salinity flux can be predicted and effects minimized. Diluting the salinity could be accomplished with a freshwater well as part of the overall water supply. Groundwater has a constant temperature of 68-70°F and might have to be slowly blended with bay waters or added gradually to a pond. Increasing salinity is more difficult as salt water wells are a hit or miss proposition and artificial salts can become expensive.

Ponds should be prepared prior to stocking. Wild fish can be eliminated with rotenone or by draining the pond completely and allowing air drying of the bottom sediments. Ponds should be filled one to two weeks before stocking with juveniles and fertilized to establish a healthy plankton population. If the culture organism is to be reared on natural pond food organisms, then a sample should be taken prior to stocking to insure the correct food organism types and abundance are present. Actual numbers of organisms stocked should be carefully determined for proper management and production estimations. Acclimation of organisms to temperature and/or salinity should be done at the rate of 2°C or 2 ppt per hour. Stocking is best accomplished at sunrise or sunset.

B. Cages and Net Pens

Cages and net pens are enclosed culture units with a similar function of being used in large open water bodies such as bays, sounds and lakes. Cages are usually smaller and more rigid than net pens and the two terms are used interchangeably in this discussion. Basically a floating cage is composed of a frame to hang netting and floats. The netting can be made of synthetic fiber, plastic covered hardware cloth, plastic netting, or expanded metal. The netting material should be selected according to sea conditions and the size of the fish being cultured. Cages can be arranged in rows, often referred to as a nested system, with catwalks which fix cages in place and allow access, or floated and anchored as single units spaced apart to allow maximum water exchange. Successful large floating cage systems exist in Japan (yellowtail) and in Europe (salmon). In one bay in Japan, more than two million yellowtail are cultured in an area of 1650 acres (1200 fish/ac).

Floating cages are divided into rigid and flexible cages. Flexible cages are inexpensive, light weight, made of readily available snythetic materials, and have low mooring loads. Disadvantages include limited type of material with a short life span, that they may collapse in rough weather crowding and stressing fish, are easily fouled and hard to clean, have a higher risk of failure as net material ages, and may require a double net to protect culture organisms from predators. Rigid cages have higher costs, longer life spans, more choices in mesh materials, are easier to clean, do not collapse easily causing less stress on fish, do not need predator nets, are easier to nest into units, and are more succeptible to damage from drifting objects. Floatation may be accomplished in a number of ways using a variety of materials. However, most floats are styrofoam or a high density urethane foam and are usually incorporated into catwalks, 3 feet wide, on two sides of the cage. Cages are moored with chains and anchors and nested together with cable and/or catwalks. Birdnetting is usually placed over the tops of the cages to protect the crop from depredation.

Choosing a site for a cage culture operation is s difficult and time consuming task. A site must be monitored over all seasons to determine water quality, stocking densities, and hydrological conditions. Maximum waves such as storm waves must be known and the system located where maximum waves will not break. Without local knowledge of tidal currents, they are difficult to quantitatively predict at a given point under varying conditions. A good site whould have mild currents, seldom exceeding 1.0 m^3/sec and very short intervals of slack water conditions. Fast currents will create a high drag force and collapse the cage. Water velocities within the cage should be lower than those outside the cage. Minimum currents will help determine the maximum carrying capacity of the cage (Ansuini, 1978). During rough seas or known seasons of rough seas, nested systems are usually reinforced with additional netting. Cages may also be sunk 4-5 feet below the surface. Some systems will have a type of breakwater in front of the system which reduces wave action but allows water exchange.

Biofouling of cages should be addressed during the design and planning stage. Cages must have sufficient buoyancy to function properly and fouling can increase the weight of the cage, the drag of the cage, and limit circulation. Net cages in high fouling areas need to be cleaned constantly and require frequent replacement. Synthetic nets may lose 50% of their strength within 3 years due to degradation from the elements, fouling organisms, culture organisms, and the sun. When replacing netting, mesh size is usually increased correlating with increased growth of fish and allowing greater water exchange. Treating with copper based anit-foul agents can reduce fouling by as much as 50% and extend the life of the net. A 90:10 copper-nickel expanded metal mesh, although expensive, retards fouling and is easily cleaned. Herbivorous fish such as mullet can be a good fouling control, but may destroy synthetic nets. Production of the cage varies with the size of cage, the location, the culture organism, and the level of management. Production has been reported to range from 0.06 to 0.76 $kg/m^3/day$ for various fishes grown in seawater. Feeds must be nutritionally complete as the caged fish are totally dependent on the feed to meet all their requirements for growth. many artificial feeds are supplemented with chopped trash fish. Feed management is in need of improvement. Best conversion is obtained with hand feeding, but auto feeders require less labor. Grading the fish periodically is important as smaller fish of many species will quit growing if they get too far behind in weight with the larger fish in a cage. Also grading is important in sending a uniform crop to market. Access to the cage is extremely important for feeding and harvesting. Caged fish are more susceptible to diseases and require careful monitoring. Usually a bag can be built to place around the cage while diseased fish are being treated.

Costs of cages vary with the system and the design. In general, the cost of a cage decreases with increasing volume of the cage. Net pen cages may have 28-41% of the total cost in the floatation system, 15-23% in the cage and netting, 23-24% in mooring system, and the remaining 20-26% tied up in bird and predator netting and miscellaneous materials (Chua and Teng, 1980). The overall scale of the operation will affect farming economics and cost of the unit cage. Operating costs are primarily tied up in feed (35-55%), seed stock (10-24%) and labor (8-27%). Returns can be high if nothing goes wrong. However, risks can be substantial from disasters such as storms, disease, fouling and mechanical problems. Management is the key to success.

C. Stock Enhancement as a Mariculture Tool

Many fisheries resources require management in order to prevent resource depletion. The stocking of fry or juveniles (fingerlings) is one such suggested technique to enhance a natural fish population. Since most species are dependent upon the estuary as a nursery area, the estuary site is a logical choice for stock enhancement. However, conflicting views, which have yet to be firmly resolved in the literature, require the stock enhancement technique to be selectively utilized with caution.

All populations show changes in abundance through time. The fluctuations are controlled by a changing balance between the birth and death rates and availability of resources. Natural selection maximizes the fitness of the population for its environment. However, genetic factors such as mutation and migration act on the population to increase genetic variation which is necessary to enable the population to adapt to a constantly changing environment. This causes the population to be in equilibruim with its environment. No population will stay at equilibrium for all time, but rather wanders about the equilibrium point, which itself would move as environmental change occurred. Year to year variations as well as long term trends in abundance can affect population equilibrium. Abundance may also vary with the season.

The success of a population, in terms of abundance or critical standing crop (that point above which natural food is not sufficient to sustain both body maintenance and maximum potential growth rate), is believed by many fishery ecologists to be dependent on available habitat at all stages of an organism's life cycle, especially the breeding and larval stages. Available food and environmental changes also affect the critical standing crop. A population, as stated above, will then exploit its available habitat, maximizing its population until reaching its critical standing crop, where the population will then come into equilibrium with mortality (death, predation, pollution, commercially fished, etc.) and its environment. The question arises as to whether or not too much pressure, in terms of habitat loss through development, pollution, and overfishing, placed upon the population will result in the maximum never being achieved. That is, mortality exceeds replacement and enhancement of the population through artificial means becomes a possible alternative. However, equilibrium must still be addressed and it could be argued that even if the population is decreasing (habitat loss, etc.) equilibrium of the ecosystem is being maintained. This would result from the effects of fishery-independent changes such as environmental changes or fishery-dependent changes such as oscillatory adjustment of predator-prey relationships. That is, the system will adjust to the depressed population by reacting to changes in the environment or by causing changes in the abundance of other organisms. The net effect of both will be to maintain overall system equilibrium.

For example, white shrimp (<u>Penaeus</u> <u>setiferous</u>) are abundant in Apalachicola Bay. They are prolific spawners and move into the estuary during their nursery phase of growth. East Bay is the only protected nursery area as commercial shrimping is presently allowed throughout the remainder of the (nursery) estuary. Many organisms eat shrimp at some stage of their life cycle, so the shrimp population is constantly being predated. Commercial shrimping adds to the overall mortality of the population. The question arises as to whether this pressure is depleting the population and endangering the survival of the resource, or does the pressure merely result in the shrimp population responding with greater fecundity to return the population to its normal balance. Local residents are divided on the issue with some feeling the entire nursery should be protected from overfishing, while others believe that East Bay is a sufficient nursery area and the shrimp resource will never be depleted. Enhancement of the resource by artificially stocking hatchery reared post larval shrimp (3 week old shrimp) or juvenile shrimp in East Bay may result in maintaining shrimp catches in the bay at current levels. However, stocking post larvae may only result in an increase in larval predators ultimately restoring the system to equilibrium with no net effect on the shrimp fishery for the cost incurred. An enhancement program such as this would require more careful study prior to recommendation.

The bulk of evidence is presently against the stocking of larvae as a means to enhance a fishery. During the first third of this century, millions of larval plaice, sole, flounder, turbot, sea bass and mullet were produced in European hatcheries and released into the North, Baltic and Irish Seas. It was never clearly demonstrated whether or not these mass releases had added significantly to naturally occurring stocks. The program was eventually abandoned.

The case against stock enhancement has three major arguments: The enormous scale by which it would have to be carried out to give a significant effect; the difficulty of confining and hoped for return to the country paying for the effort; and the doubts concerning the ability of artificially reared fish to survive the natural environment. For example, Alabama released striped bass fry for a number of years with no noticeable effect on the fishery.

Enhancement can best be accomplished in the early life history phase of a fish. Reducing mortality by even a small percentage during this early stage may increase by several fold the number of mature fish available for harvest. Some researchers feel the success of many fisheries has or will depend on the contribution of hatchery reared fish and has become a major strategy in some fisheries management programs. A major problem is that all newly hatched marine fish are inefficient feeders and take time to perfect the skills necessary for food capture. This is a delicate or critical period of change and is highly dependent upon food availability. Thus, the evidence suggests that expansion or development of hatchery releases may not be the most cost effective means for improving a fishery, but rather the raising of fry to a larger juvenile size, where they are better fitted for marine survival, and then releasing those juveniles may be a more cost effective technique. The theory is that by raising the fry to a larger sized juvenile or fingerling, the fish bypasses the critical food availability period and certain nursery habitats normally required for growth. The fish will then spend less time in the nursery and be recruited to the fishery much sooner. A research need is to understand the juvenile stages and the behavioral and physiological factors the juvenile must go through to prepare to leave the estuary and live in the ocean. Therefore, the control of the fry-to-juvenile process through environmental manipulation, to fit specific resource management needs, should lead to an improved adult contribution to the fishery.

The juvenile or put-and-take enhancement technique has been shown to work well with anadromous species including salmon, striped bass and sturgeon. Alabama now raises striped bass to a 5-6" fingerling, tags the fish, and releases them into rivers and bays. The tagged fish are now showing up in the fishery. South Carolina also has such a program for both striped bass and sturgeon and Texas has recently demonstrated the feasibility of releasing red drum fingerlings to enhance depleted populations in bays and estuaries. Salmon fisheries have been enhanced for 100 years and ocean ranching of salmon in Alaska has shown positive results.

The prospectus for stock enhancement as a mariculture tool for Apalachicola Bay requires more time for study and development. At present, the stocking of fish fry or post larval shrimp is a questionable enhancement technique and is not recommended (shrimp enhancement is discussed further in the assessment on peneaid shrimp.). As marine fingerling spawning techniques improve and as the critical larval to fry growth and feeding stage is worked out, enhancement of the fisheries with juveniles will become more probable. A hatchery (such as the one described in the oyster plan) capable of rearing numerous species and fingerling ponds for fry growout will need to be developed. Numerous marine finfish could then be spawned and eventually added to the natural fisheries. However, protection of both the nursery grounds and the maximum amount of habitat may in the long run, be the most cost effective method of preserving the fishery resource.

One final, although indirect, method of protecting the fishery resource of the estuary is the artificial reef program. Creating habitat would allow a species a greater opportunity to exploit its environment and sustain maximum population densities. Constructing more oyster reefs is a good example of expanding habitat in the bay and would benefit small fishes and invertebrates inhabiting oyster reefs. Creating habitat for blue crabs, shrimp and larval fishes in the estuary should be explored. For example, the Japanese build small concrete units which essentially are a series of parallel slabs, place the units in waters of appropriate salinity, temperature and plankton density, and then stock the units with juvenile abalone which remain in the unit until harvest.

The major emphasis should be an expansion of the offshore artificial reef program. The Japanese have considerable experience in offshore reef construction and the Florida program has borrowed from the Japanese expertise. The profile of an artificial reef is very important and the higher the reef is built above bottom, the more useful the reef is as habitat. Nearly all fishes which spawn and live throughout their life cycle offshore would utilize the reef including snapper, grouper, scamp and albacore. The benefit to the estuary from offshore reef construction lies in the reduction of some of the fishing pressure on the estuary. Commercial and recreational fishermen will spend more time out of the bay by fishing the artificial reefs. The estuary and its inhabitants will then have a little more time and space to grown and mature.

V. SELECTION OF A MARICULTURE SPECIES

Initially, criteria for selecting an aquaculture species were limited to the species taste, growth rate, hardiness, feeding level on the food chain, and availability of seed stock. Over the years the process of selecting an aquaculture candidate has become much more complex due to economic considerations, environmental factors, improved culture technology, and changes in consumer attitudes. The bottom line is that the species must command a sufficient selling price in the marketplace to offset all production costs allowing the culturist to realize a profit. Selection criteria for a potential aquaculture species have been broken down into four categories in Table 2. Decision makers in both the public and private sector must consider all the criteria and answer tough questions prior to selection. The private sector must ultimately look at profit and loss, while the public sector must consider the expense involved in research and demonstration of the candidate species to insure the greatest amount of benefit is retured from the tax dollars expended in developing a potential new aquaculture industry.

Biotechnical criteria have to do with the degree of control of culture from egg through harvest of an aquaculture species. Control of reproduction allows the culturist to operate outside of normal time constrictions of natural spawning and eliminates the need to collect seed from the wild. Complete control also assists in securing capital from investors or lending institutions. eutrition of the organism is a crucial consideration. Many species, especially marine finfish, must be fed a live food during early life stages. The ability to adequately supply live food and rearing from larvae to stocking size are factors which must be considered prior to final growout expectations. Species whose nutritional needs are well understood and who readily accept artifical feeds should receive a higher priority. Growth rate and the physiological behavior and environmental factors which influence growth rate are important biological considerations. Too slow a growth is not favorable since the costs of maintaining a high density population over a long period will tie up investment dollars too long and increase the risk. Shorter growout is more versatile to respond to fluctuating market variables and the culturist can make profitable adjustments to demand for product size, form and volume (Webber 1976).

The susceptibility of a species to diseases and parasites affects its potential for culture. Rapid assessment of an organisms health will reduce the risk of diseases and increase the suitability of the organism for culture. Species selected should be hardy and able to tolerate a wide range of environmental fluctuations including temperature, dissolved oxygen, salinity, pH, and organic waste matter which may all affect growth rate and survival. A species is preferred if it can withstand crowding and is not cannibalistic as a lower cost per unit of production can be achieved. Harvesting should be relatively simple and efficient. In summary, a culturist would seem to fare best by selecting only those species which have already been successfully bred and reared in captivity and for which management techniques are established.

The availability of appropriate sites for culture is fundamental to development. Selecting a site in the marine environment is tied to both the specie under consideration and the type of culture system employed. The organism will usually determine where in a bay and at what depth in the water column it will grow and survive best. The exception is if the species is to be cultured on shore in ponds or tanks. Onshore and intertidal sites have the advantages of availability of electricity, easy access, and drainage capability. Exposure of a bay site to wind, waves, tides and tidal currents may adversely affect the culture structure (cages/net pens) or cause undue stress to the organisms under culture. Conversely, a large number of cages or pens may affect the normal hydrography of a bay. An adequate supply of good quality water is essential and if not readily available will drive up the cost of production. If a bay site has a large amount of freshwater influxes as does Apalachicola Bay, then the candidate species must be able to tolerate rapid changes of salinity. Hurricane records should be examined to determine the frequency of such an occurrence at the culture site. Finally, competition for a site from alternate uses must be evaluated.

Finding an end use or market for the cultured product is a major consideration. Knowing who will buy it, what times of the year it will be bought, and how much the consumer is willing to pay for the product must all be thoroughly studied prior to a species selection. Consideration must also be given to the kind of product cultured; whether large volumes of low priced food for feeding masses of people are to be produced or whether less quantities of high priced food items for a luxury market are to be produced. Presently, most successful aquaculture operations fall into the luxury category. As long as this market exists, an operation can make more money per unit of space and effort raising a $2 a pound product than raising a 10 cent a pound product (Lindbergh 1984). The cultured product must be acceptable in terms of taste, odor, color, texture, and appearence of the processed product in the fish showcase at a retail outlet. If restaurants are the target market, then these acceptable factors become even more important. Knowledge of market behavior will provide useful information to the culturist on changes in supply and demand and changes in the size and structure of the market which all impact the price of the product. The higher the identifiable local market for an aquacultured product, the greater the opportunity for commercial development. Identifying regional and national markets will also boost the chances for commercial success. Being able to service a market, especially a local market, on a regular year round basis will add credibility to the producer ultimately resulting in increased sales. Competition from both the wild catch commercial fisheries and other aquaculture operations must be continually assessed in terms of price, quality, quantity and regularity of service. The larger the natural fishery, the harder it may be for a cultured product to compete in the marketplace. However, learning to exploit the seasonal availability of wild caught species during their offseason will produce greater returns to the culturist.

Ability to earn a profit over the cost of culture is the most important economic cnsideration in selecting a species. Investors demand the return on investment be short enough to be profitable. Keeping the cash flowing will reduce investor anxiety as opposed to a crop which takes too long to reach market. The potential profitability is based on state of the art culture, structure of the market, and past or demonstrated performance of the species under consideration. The degree of risk must also be assessed by investors and lending institutions. Risk may include the past performance of the species to be cultured, the expertise required to operate and manage the business, the estimated time necessary to develop the operation commercially, and the legal and social barriers to development. Sources of capital must be identified. Lenders who understand an operation will have greater confidence in its potential profit and be more inclined to offer loans. Finally, since an aquaculture venture requires a considerable period of time prior to the first cash crop, the culturist must make sure the amount of capital borrowed is sufficient to meet all unexpected problems.

Social factors are the last category to be considered in selecting a candidate species. The traditional food habits and taboos of the targeted market need to be known as does the identity of the product by different sectors of the population.

Targeting the selection of a species towards social habits of people living in the local area will increase the marketability and ultimately the success of the product. Analysis of the available labor force in the area and the wages which will be accepted are needed to help project costs. Other competition for that available labor must also be known. Social barriers to import, culture and sale of a potential species may impact on the suitability of the species for culture. Legal barriers may be a significant constraint to culture. The time and energy expended in securing permits may dilute the energy of the culturist to the extent that the operation suffers and risk increases.

A checklist of criteria such as those found in Table 2 should be used to rank or evaluate each candidate species. It can be a stepwise progression with each step analyzing fewer species in greater detail. Species with the greatest potential will then be identified and supported by the procedure.

TABLE 1

Aquaculture Candidate Species Selection Criteria

I. Biotechnical/Culture

Availability of life history information
Physiological requirements
Environmental influences
Reproduction

- availability of seed/fry/juveniles
- maintainance of broodstock
- controlled reproduction in captivity
- breeding programs/genetics
- rearing of fry/available food sources for fry
- survival of fry to juvenile stage or stocking

Nutrition

- Dietary requirements of organism well understood
- Brookstock, fry, juveniles, adult feeding rates known
- Live food availability
- Artificial feed available
- Feed conversion efficiency
- Trophic level of organism

Stocking Rate
Intensive high density culture potential
Hardiness
Territoriality/Cannibalism
Water Quality Parameters
Diseases and disease resistance
Growth rate
Time period for growout
Survival to harvest
Ease of harvesting
Success of previous culture attempts

II. Siting/Systems

Site selection

- shore
- intertidal
- sublittoral
- surface/floating
- midwater
- bottom

Culture system

- ponds
- raceways
- tanks
- cages/net pens
- impoundments

Exposure

- wind
- waves
- tidal influence
- currents

Water source and availability
Rate of runoff/river influence
Freedom from hurricanes and floods

III. Marketing/Economic

Potential economic use of product(s)
Cost of culture
Return on investment/potential profit
Degree of economic risk
Time period necessary to develop operation to success
Sources of capital/financing
Flavor, taste and odor acceptability
Appearance of fish and of whole animal
Color, luster, form and texture of product
Processing

- dress out percentage
- ease and cost of harvesting and handling
- rate of tissue decomposition/shelf life
- shipping and distribution

Market behavior

- pricing of product(s) as food/bait
- size and structure of market
- supply and demand elasticities
- identification of local, regional and national markets
- servicing of market year round
- competition from commercial fisheries
- location to markets

Recreation potential

IV. Social Factors

Traditional food habits and taboos of targeted market
Identity of product by different social groups
Available labor force, wages, and competition for that labor
Poaching/vandalism/theft
Legal barriers

- permits and licenses
- time, cost and operators energy required in obtaining permits and licenses
- nonindigenous species
- competing uses of culture site

VI. Species Assessments

The preceeding section provided criteria for selecting a potential aquaculture candidate. This section reviews numerous species with potential for culture in Apalachicola Bay. The species chosen in this section are either currently found in the bay or have a high market value. Selection criteria were then assessed for each species to the extent of available information in the literature or by personnal communication from fish culturists. Not all criteria could be assessed for each species indicating the need for further research and demonstration. The assessments are not presented in any particular order.

A. Sciaenids

1. Red Drum or Red Fish

Red drum (Sciaenops ocellata) are believed to spawn offshore at age 2 or 3 from September to February peaking during October. Estuaries are nursery grounds for red drum and the amount of available habitat appears to be directly related to recruitment. As red drum grow they spend less time in estuaries and more time in shallow ocean areas. While they may feed throughout the water column, they prefer benthic organisms, particularly shrimp and xanthid crabs. Red drum are both commercially and recreationally fished. Over 6800 lbs. were landed in Franklin County in 1982 averaging $0.46/lb. This represents a 30% decrease in landings over the past four years, but nearly a 20% increase in price (NMFS).

Red drum have excellent aquaculture potential. A state hatchery capable of producing 10 million fingerlings each year is in operation in Texas (they have actually stocked 14 million fingerlings in two years) and a private firm has established a facility in the Bahamas. Within the next two years the F_1 generation fishes in Texas should spawn. The DNR has spawned, reared and maintained red drum for over a year in tanks.

Colura et al. (1976) stocked a 0.4 ha (.98 acres) pond with red drum at 335,000 fry/ha, ten days after initial pond fertilization. Higher stocking rates of 300,000-500,000 fry/ac have been achieved. Only 63,914 fish were recovered for a 45% survival and production of 67.5 kg/ha (60 lbs/ac) or 2.17 kg/ha/day. Salinity was 20%, fingerlings averaged 0.42 gm and 31.7 mm, and fed on zooplankton throughout the period. The success of the system relies on the ability to remove predators from the ponds and maintain a high density of naturally occurring food. Laboratory larval rearing is more costly, labor intensive, and rarely yields more than 25% survival. Pond rearing can produce a 1-1.5 inch fingerling in 30-40 days.

First year growth may average 365 mm and 950 gm. A 0.08 hectare pond was stocked with 11.0 gm red drum at 4213 fish/ha. The fish reached 335 gm and 316 mm in 290 days with excellent survival and production of 935 kg/ha. The fish were fed commercial catfish chows and had an FCR of 2.7:1. Growth from fingerlings ranging from 2-6 lbs. has been reported over two growing seasons (18 months). Further research is needed in reproductive biology, diet and nutrition, grow out, winter survival, and in decreasing production costs while increasing yield. Market research is needed to determine if the product can be produced and sold profitably and competitively with the wild fishery. Preferred market size must also be determined. A 3-4 lb. fish will dress out to two 9-10 oz. fillets, requires at least two growing seasons and will bring a high price. A 1-1.5 lb fish can be cultured in one year, but must be sold as a pan sized fish (headed, gutted and scaled). Texas extension specialists report gutted redfish sold for $0.75/lb. during winter and reached $1.90/lb. during the 1984 Lenten season.

Red drum are relatively easy to spawn and rear to market size. They can grow in waters which are fresh to highly saline, have good growth rates, readily accept artificial feeds, can be seined from ponds, and do not succumb to low temperatures unless the decline is very rapid. Low temperatures do inhibit growth, and death resulting from termal shock is more prevalent in freshwater (7°C) than in saltwater (2°C). The Texas program is stocking red drum into freshwater areas as a predator for sunfishes and as a sport fish for recreational anglers. The program is also stocking fingerlings into bays and estuaries as a fisheries enhancement tool.

This may be the most promising area for red drum culture if natural stocks continue to decline and the competition between commercial and recreational fishermen grows. However, the costs of such a program compared to the expected benefits have not been determined.

The major constraint to red drum culture in Apalachicola Bay is the low price paid to fishermen for red drum caught in this area of the Gulf of Mexico. So while red drum are an excellent aquaculture candidate, the economics of production would, most likely, be a limiting factor. At such time when the value of red drum increases, their commercial culture will become feasible. The development of red drum culture in Texas by the private sector should be monitored closely for applicability in Florida.

2. Black Drum

Black drum (*Pogonias cromis*) are an inshore species found over sand and sandy mud bottoms. They especially like areas of high runoff and sheltered areas such as bridges, docks and piers. They average 1-3 lbs in weight, but have been known to live 35 years and reach over 100 lbs. Black drum reach sexual maturity after two years and spawning occurs from late winter to spring.

Black drum is much like red drum in that it is an easy fish to spawn and rear. Branch and Strawn (1978) reported that black drum grow rapidly, are carnivorous benthic feeders, and tolerate a wide range of both temperature and salinity. They grew Black drum in ponds with mullet and noted a 17% increase in production of the polyculture (532 kg/ha) over the monoculture (444 kg/ha) of only Black drum. Survival in both experiments was 95%. Fish were fed a 30% protein catfish chow at a maximum of 5% of their body weight during warmest months.

These same researchers grew Black drum in $0.16m^3$ cages in a brackish power plant cooling lake. Survival was excellent with growth rates of 0.98 g/day (compared to 2.57g/day in ponds). The work suggested that low salinities or rapid salinity fluxes inhibit growth.

Black drum primarily utilize Apalachicola Bay as a nursery area, but adults are often found in the bay during warmer months. Black drum can also be a predator of oysters. The major constraint to Black drum aquaculture at present, is the low price of the fish which may sometimes sell for $0.15-0.20 per pound. As demand and price both increase, Black drum will become a more likely aquaculture candidate.

B. Snappers & Groupers

Grouper, native to the Gulf, with culture potential include the red grouper, *Epinephelus morio*, the gag grouper, *Mycteroperca microlepis*, the black grouper, *M. bonaci*, and the scamp, *M. phenax*. Only the black grouper may be found in the Apalachicola Bay during warmer months. Grouper spawn offshore in deeper waters with most species spawning during spring. Larvae are pelagic. Juveniles may inhabit grass flats and in general, move into deeper waters with growth. Adults are reef fishes, and usually stay close to protective holes or other cover. Groupers may live 25 years or more and may reach weights up to 30 lbs and lengths up to 30 inches. Most groupers begin life as females (protogynous hermaphrodites), reach sexual maturity at 2-4 years, and may transform into males after 5 years of age. Groupers are carnivores. In Florida, they have a minimum size limit of 12 inches.

Roberts, et al, (1983) have spawned gag grouper (*M. microlepis*) in captivity with hormones. Since males live in deep water and don't survive capture well, captured females were given an oral application of methyltestosterone to induce sex inversion. Mated females were then strip spawned and the larvae reared for 15 days at which time they died. Controlled reproduction requires a 10 month conditioning period with a 10 hour light photoperiod at maturation, a temperature change of 28-30°C down to 21-23°C, and hormone injections to induce ovulation. Fertilization rate was 50% and larvae hatched after 45 hours at 21°C. Newly hatched larvae are only 2mm in length. Larvae must be fed a live food and rearing them up to fingerling size is, at present, a difficult task.

Inducing females to spawn is no problem, however, the strip spawning process must be done under optimum conditions and with perfect timing. Thus, time sequencing of spawning needs more refinement so that the resultant fertilized eggs are of good quality. Increasing the knowledge of the fishes' lifestyle and increasing the overall effort would result, most likely, in commercial hatchery feasibility and rearing larvae well past 15 days. One interesting technique would be to transform a female into a male, freeze its sperm, allow the male to revert back to a female, and then spawn the fish using its own sperm.

Grouper larvae will eat plankton, rotifers and copepods. Adults are easy to feed and will consume most any chopped fresh or frozen seafood. Gag grouper should be able to live and grow in lower salinity waters found in Apalachicola Bay, but winter temperatures may be a problem as lower tolerance is estimated to range from 15-18°C. Gag grouper will grow about 14 inches per year and are fairly robust which makes for thick fillets.

Chua and Teng (1980) have performed extensive research on rearing of the estuarine grouper, E. salmoides, in floating net pens in Asia. Much of the work may be applicable to groupers indigenous to the Gulf of Mexico. Controlled reproduction of this species is also a few years away from commercial feasibility. These fish reduce their rate of O_2 consumption as the oxygen concentration in the water decreases. Metabolic rate (growth) is reduced below 3.7 mg/l and oxygen in the cage should not be below 50% saturation. Temperature tolerance ranged from a low of 10°C to a high of 39.5°C. The salinity where the fish is naturally found ranges from 26-31 ppt, but best growth occurred at 15-26 ppt. The lower lethal salinity limit was 2.5 ppt.

Cages were 1.5m x 1.5m x 1.65m ($3.33m^3$) made with polyethelene netting with a 12.5mm mesh and wooden frame with floats for support. Cages should be located one meter off the bottom at low tide, which prevents disturbance of the benthic community and minimizes disease. A current speed of 0.2-0.5

meters per second was adequate to insure oxygen levels and flush the cage. Current speeds above 1.5m/sec. were too high and caused stress and reduced growth. Fouling was a major constraint. Water exchange through a 37.5mm mesh may be reduced by as much as 60% in two weeks. Sharp edges of some fouling organisms may eventually tear netting and allow fish to escape. Netting must be routinely inspected, cleaned and replaced. Low labor costs in Asia allow for the efficiency of the system.

Fry in Asian net pen culture are presently obtained from the wild. Chua and Teng found optimum stocking densities to be 60 fish/m^3. They stocked 54gm fish (3.35 kg/m^3) at 60 fish/m^3 (200 fish/cage) and fed the fish chopped trash fish for six months until they reached market size (500 gm). Net production was 23.7 kg/m^3 (173.6 lbs/cage). Mortality ranged from 15-20% with 5-8% attributed to cannibalism of fish less than 15cm in length. Feeding trash fish produced a FCR of 3.9:1 and a net average gain of 432 gm per fish. Artificial feeds with a 40-50% protein content resulted in a faster growth rate and FCR of 1.9:1. Fish were fed to satiation once every two days. Food intake is a growth limiting factor as grouper require 36 hours to completely consume all food. Total cost was $2/kg ($0.91/lb).

In another test, the researchers used growth promoters, such as 17__ methyltestosterone and nitronin to increase growth by 43% and 62% respectively. It is unlikely that these promoters could be used in fish sold as food. The researchers also found that fish grew better if a hiding space was provided much like that found in its natural environment. A hide space of 25 cm^3/fish was found to be optimum. Stocking density could then be increased to 156 fish/m^3. Addition of both hide spaces and growth promoters at the increased stocking rate produced marketable fish in 2.7 months. Production increased to 136.7 kg/m^3 and cost dropped to $1.28/kg ($0.58/lb).

Prices paid for grouper vary by season and location in Florida. In Apalachicola, a low of $0.70/lb might be paid during winter. The highest price paid to fishermen is $2/lb. In South Florida prices may be as high as $3-4/lb. Landings have nearly doubled over the past four years with average prices rising $0.12/lb. reaching 743,000 lb. at $1.02/lb. average in 1982 (NMFS). Overall, the gag grouper and possibly the black grouper have excellent culture potential. The adaptation of grouper to estuarine conditions especially the accelerated growth rate at estuarine salinities, along with acceptance of artificial feeds, good conversion, and use of cages with hide spaces make grouper a promising aquaculture candidate. Low water temperatures during winter in Apalachicola Bay coupled with fluctuating market prices may be constraints which may be solved by growing the fish during warmer months and targeting marketing to coincide with gaps in the commercial fishery. Closing the spawning cycle, rearing fry to fingerlings efficiently, hybridizing the fish to tolerate lower temperatures and salinities, and eliminating problems with net-pen culture will be necessary before full commercial production can be achieved. Preliminary feasibility of net-pen culture of grouper in the bay might be demonstrated through a research project under the guidance of ANES.

Culture success with red snapper, Lutjanus campechanus, is about at the same status as grouper. Complete life history of snapper including spawning locations, seasons, descriptions of eggs and larvae, and habitat preferences are not well understood. Habitat varies with species, but in general as fish grow and age, they move out to deeper waters where hard bottoms or reefs are found. Snapper are both a commercially and recreationally important species.

Red snapper have been spawned in Florida, Alabama and Texas. They can be striped spawned using HCG or spawned naturally during May and June in tanks by manipulating photo period at 15 hours light, 9 hours dark, and 23-25° C and 31-34 ppt. Larvae are very small and hesitant to accept feed. Very small rotifers and copepod nauplii have been used as a food source, but all trials have terminated by day 5 posthatch with complete mortality. There have been no attempts to raise fry in fertilized ponds all the way through juvenile stage. Growth of adults has been observed in ponds (1.7cm/month) and adults are able to withstand low salinities. Snapper must be overwintered when temperatures fall below 15° C.

The price of red snapper is a major aquaculture inventive as it may go as high as $3.00-$3.50/lb. in Apalachicola. From 1979 to 1981, red snapper landings increased in both pounds and dollar volume - landings decreased in 1982 to 1980 levels of roughly

50,000 lbs/yr and the average price has remained stable at $2.04-$2.09/lb. for the past three years (NMFS).

C. Spotted Sea Trout

Spotted sea trout (Cynoscion neubulosus) are found in Apalachicola Bay and are highly sought by both recreational and commercial fishermen. The fish are mostly non-migratory spending nearly their entire lives in estuaries. Each estuary has its own brood stock with spawning occurring in spring and summer. Habitat includes seagrass beds, marsh and oyster reefs. Sea trout are carnivores and feed on a variety of organisms with fish becoming more important to their diet as they grow. Trout will move out of the estuary when temeratures drop below 15°C. Commercial landings in 1982 were 52,951 lbs. with an mean price of $0.70 lb. (NMFS). Recreational landings are believed to be equal to or greater than commercial landings.

Colura et al (1976), have spawned spotted sea trout in Texas. A 15 hour light, 9 hour dark photoperiod at 26°C and 30 ppt resulted in a high percent fertilization and subsequent hatching after 18 hours. Larvae were fed rotifers and brine shrimp. Fry were stocked in a 0.1 ha pond at 50,000 fry/ha and 20 ppt. Only 11% of the fingerlings were recovered with production of 5.89 kg/ha (0.19 kg/ha/day). Growth was poor with copepods the primary food and polycheates, amphipods and palemonid shrimp secondary sources of food. Less than 3% of the total food consumed was commercial feed.

The work concluded that stocking older fry would be advantageous. The large mortality loss was due to intense cannibalism. Coupled with inadequate food sources, especially the inability to accept commercial feeds, the researchers concluded that spotted sea trout were not a suitable aquaculture species. Once early age culture is perfected, there may be a possibility of culturing trout to fingerling size and releasing them into estuaries as an enhancement tool to replace declining stocks. This may be a long range consideration for Apalachicola Bay due to the tremendous recreational fishery attributed to sea trout. Sea trout, along with red drum, is the most sought after recreational fish in the grass flats of the bay and tidal creeks of the river delta.

D. Pompano

Pompano (*Trachinotus carolinus*) have been caught in Apalachicola Bay during spring and summer when water temperatures exceed 20°C. Pompano are much more abundant in offshore waters as higher salinities are preferred. Very little is known on the basic biology and life history of the pompano or its relative the permit (*T. falcatus*). Pompano are believed to be offshore pleagic spawners with an estimated fecundity of 426,000-630,000 eggs. Peak spawning occurs from April through June, but may range from February to October in Florida. Juveniles are found in the surf zone on open beaches with sandy bottoms. The wave action uncovers benthic invertebrates which, along with pelagic invertebrates and larval fishes, form the basis of a juvenile's diet. Adults are more oriented towards eating molluscs and fish. Pompano are hardy fish which can withstand a wide range of pH, salinities and turbidities. A DO of 2.5ppm and temperature of 10°C are considered lethal.

Pompano are an excellent food fish which command a high market price. Pompano are commercially fished all along the Atlantic and Gulf, but 90% of the catch is landed in Florida. Pompano comprise less than 1% of the commercial landings in Franklin County with only 380 lbs landed in 1982. Commercial fishermen presently receive an average of $2.09 per lb., but it may wholesale for $4.00 per lb or more. Pompano are also widely sought by the recreational angler. Pompano must be a minimum of 9.5 inches fork length and are regulated by Chapter 370, F.S.

Culture of pompano received much attention in Florida in the late sixties and early seventies by some large corporations and several smaller operators. Only a few crops reached market and all operations have since ceased. All failed because of an inadequate technological base. All attempts were dependent upon the capture of wild fry as seedstock. Juvenile pompano are abundant in Northeast Florida from April to November, are easily haul seined, and are hardy enough to be transported.

Moe et al, (1968) made preliminary evaluations on pond culture of pompano in 1967. They stocked saltwater ponds at three random densities. Temperature ranged from 10 to 27°C and salinity was 30ppt. Fish were fed either ground trashfish, up to 30% of body weight per day, or floating trout chow (Purina 5105) at 5-8% body weight per day. Mass mortalities were experienced and only 1,781 fish were harvested from 322,200 initially stocked. A FCR of 3.2:1 was estimated utilizing trout chow. They estimated a 10" pompano could be cultured from fry in 12-18 months. Data was inconclusive regarding stocking rates, growth rates and production per acre. Nutritional and environmental requirements remain poorly understood.

Smith (1973) stocked 7gm pompano at five densities (100, 250, 400, 650 and 900) in $1m^3$ cages (6.4mm mesh). Growth was best and mortaility lowest at the lower stocking rates. Mortality averaged 21% primarily due to inadequate feed. Fish were fed a 40% trout chow initially at 6.3% body weight, three times a day along with a chopped squid or fish supplement once each week. A 1 lb. marketable fish was obtained in 47-51 weeks. Feed costs were $1.70 per kg ($0.771/lb) of pompano produced. Low DO and heavy cage fouling were problems.

Hoff et al (1978) were successful with both strip spawning and semi-natural spawning of pompano using HCG. Depending on environmental conditions, the complete gonadal cycle will take from 34-66 days. Thus, it may be possible to condition a fish to spawn 4 or more times a year. Fish were induced to spawn at 23-28°C. Larvae were reared for 23 days on a diet of plankton, protozoans, rotifers and copepod nauplii.

Researchers at the Claude Peteet Mariculture Lab in Alabama worked with mono and polycultures of pompano and shrimp for eight years. Cages were originally used, but the pompano proved to be sensitive to parasite and disease problems. One-half inch juveniles stocked in ponds in late May could reach the acceptable market size of one-half pound by the end of October if no problems were encountered. Polyculture of pompano with penaeid shrimp (May-Oct) can yield up to 2,000 lbs/ac followed by a monoculture of rainbow trout (Nov-April) producing 1,300 lb/ac in the same pond. Shrimp should be cultured 30 days in a nursery pond prior to stocking with pompano to reduce predation of the shrimp.

Many problems still exist for successfully culturing pompano. Optimum stocking densities and causes of mortalities, including diseases under culture conditions, need to be assessed. Further efforts to control spawning are also needed. Pompano have a high metabolic rate which results in high oxygen consumption requiring a rapid rate of water exchange in ponds or cages. At temperatures above 30° C, it becomes virtually impossible to supply enough oxygen to high concentrations of fish. Improvements on systems engineering and more demonstration are needed. Diet and nutrition is the area with the greatest research need. This is especially true with the diet for rearing of larval pompano. Perhaps the best place to start is with studying the basic biology and life history of pompano.

Pompano command a high market price and as such, marketing should pose no problems. New markets to restaurants or with a frozen product may have to be developed in the future. No economic data is available on pompano culture. However, the high market price would allow for higher production costs. Permits are presently required to collect wild seedstock. A mechanism to differentiate between wild caught and cultured pompano would have to be developed.

The potential for pompano culture in Apalachicola Bay is not good at this time. The primary constraint is low winter temperatures in the bay which would result in mortality of the fish. Cage or net pen culture are recommended techniques for the bay while upland ponds may produce the greatest net returns. Pompano fingerlings might have to be artificially spawned and reared to a minimum of five inches indoors prior to final growout during spring, summer, and fall.

E. American Eel

Eels (*Auquilla rostrata*) are an unexploited resource in the Apalachicola River and Bay system. The fishery has never fully developed due to poor domestic markets. A limited fishery developed in 1980-81 landing 7500 lbs. averaging $0.74/lb. (NMFS). Eels are considered slimy and inedible by local residents and are not actively fished by the recreational angler. However, a domestic market does exist for 4-9 inch fingerlings which are considered excellent bass bait and for adult (one half pound or more) eels as food in cities with large numbers of Oriental Americans. An export market, which may have a 165 million pound shortage, for eels exists primarily in Japan and Europe (NADP, 1983). A fishery, consisting of both cultured and wild caught eels, could be developed in the Apalachicola system to exploit these markets.

Eels are catadromous fish in that they spawn in the ocean, but spend the majority of their lives in fresh water rivers. Eels spawn in the Sargasso Sea in the western Atlantic Ocean at depths greater than 200 meters, temperatures of 16-18°C, and salinities of 35ppt. Eggs are pelagic and soon hatch into leptocephalus larvae which are brought into shallow coastal areas by currents. This process may take a year. The larvae fall to the bottom where they bury themselves and begin the transformation into elvers. In December the elvers begin to migrate upriver which may continue through April. Migration may be triggered by a drop in water temperature or increase in water volume flowing down the river. The elvers burrow in the river bed during the day and ascend the river at night. They are commonly found at obstructions such as hyacinth beds, tidal marshes, and dams. Young elvers feed primarily on detritus. As they grow, small animals are consumed and as adults feed on worms, shrimp, crabs, fishes, and frogs. Sexual maturity is reached at 3-4 years for males and 4-6 years for females. However, eels may remain in freshwater for fifteen years or more before descending to the sea to spawn.

Eel culture is mostly practiced in Europe and Japan. Eels are not yet routinely spawned in captivity. The Japanese have done in vitro fertilization and have reared larva for five days, and the Russians have obtained fertile eggs from eels grown in captivity. However, nearly all eel farms depend on elvers captured during their upstream migration as a source of juveniles. They are usually captured with traps and nets or by attracting them to light at night. Eels can be cultured in ponds, but are usually grown in a series of tanks. Eel farms in Japan usually average 1500-2000 m^2 of tank surface area. All tanks are round or octagonal to facilitate water circulation. Fiberglass and concrete are the materials normally used for tank construction. Fingerling tanks may be as small as two cubic meters and stocked at 150-300 g/m^2 (.33-.66 lbs). Fingerlings 3-4 inches run approximately 250 to the pound. Growout tanks may be 4 ft. in diameter and 1 ft. deep and may hold 25-30 lbs/m^3. Water exchange varies, but tanks must be cleaned weekly. Sorting of eels should be done frequently to utilize space efficiently and for marketing as eels are often sold in a group of similar size. Culture in outdoor ponds is limited to small ponds, 65 X 17 X 5 ft. filled to a depth of 3 ft. Fish are fed twice a day with approximately 25% water exchange. Growout requires 12-14 months to reach a minimum market size of 1/3 pound.

Optimum water temperature for growth is 25-28°C. Most farms include a greenhouse and/or an additional heat source for elvers. The greenhouse is used to help heat water, shade fish from the sun, and avoid outside disturbances. Covers may also be employed on outside tanks as eels like to feed in quiet and under cover.

Eels are fed a prepared food containing 45% or more protein. The food is prepared daily from fish meal, corn starch and vitamin permix in a kneading machine and resembles a ball of dough. The food is immediately fed to the fish as the dough rapidly loses its viscosity. Feeding rates vary between 2-6% body weight and an FCR of 3-4:1 is the norm. Feed costs may run as high as 42¢/lb.

Costs of production are high due to the equipment, energy costs (pumping, heating, etc.), and feed. Equipment includes an oil boiler, oil tanks, generator, blowers, water wheels, various pumps, and a kneading machine. Most farms are flow through systems requiring large quantities of fresh water. Profits may be high if good markets are developed. Cultured eels are considered a better product than wild eels due to their higher fatty acid composition. Cultured eels one half pound or larger may sell for as much as $2.50/lb. from the farm. Fingerlings to be used as bait may wholesale from the farm for $4-8 per dozen. Most eels are shipped to markets live. They can be shipped live for 20-30 hours if packed in cardboard boxes containing two double layered vinyl bags with an 8 l. (8.5 qts) capacity containing 1-2 l. of water saturated with oxygen, 0.5 kg. (1.1 lb.) ice and 5-10 kg. (11-22 lb.) of live eels.

Constraints to eel farming include a steady supply of seed stock, disease and competition from the wild fishery. Reproduction in captivity is a high research priority. Florida law presently limits the methods by which elvers may be captured, resulting in a great deal of time and energy expended to collect juveniles. Diseases need to be routinely monitored in tanks stocked at high densities. Wild eels currently sell for $1 less per lb. than cultured eels.

The potential for an eel fishery, both wild and cultured, in Apalachicola River and Bay is good. A handful of wild eel dealers exist in the St. Johns River basin and there is one eel farmer who deals in both wild and cultured eels in the same area. These are potential buyers, with established markets, for all sizes of eels captured in the Apalachicola basin if the eels are live hauled to the St. Johns area. Live hauling would minimally require a pickup truck with a portable live tank equipped with bottled oxygen. One buyer also exists in Tampa who wholesales smoked eels. An alternative would be to plug eel sales into existing seafood marketing channels in Franklin county. The greatest immediate potential is the capture, holding, culture and sale of fingerlings for the recreational fishing industry. The bait business along the Apalachicola, Lake Seminole and up into Georgia and Alabama is excellent and satisfying this market may be sufficient to develop the fishery. Such an undertaking could be a component of the multi-use facility described in the oyster section. The elver season lasts approximately 4 months and the adult season all year with summertime being the slowest season. The recommendation is for the development of an eel fishery as a supplement to traditional fisheries with a long term goal of culturing fingerlings for the bait business and possibly adults for the live food market.

F. Hybrid or Sunshine Bass

The hybrid bass, (Morone Saxatilis X Morone Chrysops), commonly known as the Sunshine Bass in Florida, is a cross between female striped bass (M. saxatilis) and male white bass (M. chrysops). The reciprocal cross also produces a hybrid. The hybrids have superior early growth rates especially during the first two years of life, greater disease resistance, improved survival, better overall hardiness and are less canabalistic than striped bass. The hybrid has an outstanding potential for culture as a commercial food fish and is well suited for the conditions in Apalachicola Bay.

The striped bass (M. saxatilis) is a popular commercial food fish and recreational fish on the Atlantic, Gulf and Pacific coasts. It is an anadromous, euryhaline species. On the Gulf coast the striped bass spends the majority of its life in freshwater rivers. Spawning of the striped bass began in the 1880's and fry and fingerlings have been raised ever since for the stocking of public waters. Over 40 million fry and fingerlings were produced by state and federal hatcheries in 1982. Until recently, almost no research had been carried out on the culture of stripers to market size. Striped bass have now been successfully reared in freshwater ponds and in cages in salt water. More recently, the potential for culture to market size of the hybrid bass has been undertaken. Both the striped bass and its hybrid are found in Apalachicola River and Bay.

Striped bass are routinely spawned in captivity using hormones and then either stripping the eggs or spawning the fish naturally in tanks. Hybrids have primarily been produced by collected brooders from the wild and strip spawning after hormone injection. The brooders are sacrificed in the process which only occurs during spring. This necessitates a continual source of brooders taken from the wild which is of concern to wildlife agencies. Domesticating the two species so that the same brooders may be used year after year to produce eggs will be necessary before the full culture potential of the hybrid can be reached. One researcher in South Carolina has been able to produce domesticated hybrids without killing the brooders and to induce spawning at different times of the year. Hopefully, this work will lead to a routine supply of hybrid bass fry.

Water temperature should be 18-20° C for hatching, but can be increased to 30° C or higher after the larvae are 10 days old to accelerate growth. Photoperiod effects on reproduction are unknown, but lights are routinely used to attract both zooplankton and fry in rearing ponds at night to facilitate natural feeding. Fry are easily damaged in hatching tanks, so water inflow should be kept at the lowest possible velocity to maintain water quality. Oxygen should be maintained near saturation. Water should be slightly basic (pH, 7.3) and well buffered.

Rearing hybrid fry to fingerlings is the most crucial stage of culture. Hybrids have a smaller mouth than striped bass and rearing success is dependent upon an appropriate and abundant source of food. Nauplii of copepods, cladocerans, and insect larvae along with phytoplankton are considered preferred foods for newly hatched larvae. Assuring an adequate concentration of food is also critical. Brine shrimp are also used to feed fry as soon as their mouths are large enough to eat the brine shrimp. However, training the fry to accept prepared foods is considered to be critical as fry which are poorly trained to eat artificial feeds usually do not exhibit good growth rates during the grow-out phase of culture. Prepared food with the same particle size of brine shrimp should be included in the feeding regime when the fish are between 14-21 days old. The combined diet should be fed for 10-14 days and the brine shrimp then phased out. Feeding sufficient quantities is important in reducing cannibalism. Once fry are cannibalistic, other fry become the favorite food. Production of fingerlings is accomplished in open ponds, tanks and raceways. Survival from fry to fingerling can be as high as 50%, but 30% is a more realistic average. Improvement of survival during this stage especially in the areas of cannibalism and feeding behavior is a high research priority. Presently development of hybrid bass culture is constrained by the lack of sufficient private sources of fingerlings.

Kahrs (1984) stocked 40,000 fingerlings, 38-50 mm in length (1.6 gm) in a one acre pond with a flow of 15 gpm aerated spring water. Fish were fed twice daily with 38% crumbled trout chow. Fish learned to feed readily and averaged 127 mm in length after 60 days.

Growth is best during the warmer summer months when temperatures average 28°C. Little growth or active feeding occurs at temperatures less than 15°C. Dissolved oxygen should not fall below 5 mg/l for extended periods. Hybrids can withstand salinities up to 28 ppt; however, some evidence suggests growth is reduced at higher salinities. Resistance to ammonia toxicity has been noted in hybrids cultured in brackish water. Ammonia should not exceed 0.6 mg/l. Use of low salinity water reduces stress during harvest, handling and transportation. A pH range of 7 to 9.5 is considered optimum. Alkalinity should be maintained above 150 mg/l. Most diseases and parasites which afflict warmwater species may also occur in hybrid bass. Hybrids are more resistant to disease than striped bass and resistance is slightly increased when grown in brackish water.

Williams et al (1981), grew hybrids in estuarine waters of South Carolina in 13.6m^3 (10.5 X 8.5 X 6.3 ft) net pens similar to ones used in salmon culture. They stocked 3.0 gm fingerlings at densities of 66 fish/m^3 and fed a mixture of dry salmon feed and ground fish. Fish were fed at rates of 1-10% of body weight per day, with the percentage decreasing as mean size increased. Water temperatures ranged from 8-10°C from December through March to 25-30°C from May through September. Salinity ranged from 11-28 ppt. Fouling was a problem during the warmer months and nets were cleaned with a high pressure hose or changed monthly. Blue crabs were controlled by fishing crab traps at each end of the pen. Fish were vaccinated with a dip against vibriosis disease. Survival (88%) and growth (1.37g/fish/day) were excellent after the fish were placed on a mixed diet and size graded. Food conversion was estimated at 3.5:1. An FCR of 2.1:1 was obtained in a subsequent experiment. After one year fish averaged 310 gm and total biomass 16 kg/m^3. The researchers concluded the fish were underfed, substantially higher standing crops could be obtained, and the potential for commercial net-pen culture of hybrids in estuarine waters is excellent.

Kerby et al. (1983), cultured hybrids in freshwater ponds and in cages in estuarine waters in North Carolina. Cages were 0.5m^3 and stocked at densities of 100, 150 and 200 fish/m^3 with hybrid fingerlings averaging 44.6 gm. Fingerlings were dipped in a vaccine solution to protect against vibrosis. Fish were fed to satiation 2-3 times daily with a pelleted commercial trout chow. After 226 days survival averaged 95% and mean weight per fish 333 gm. Growth rate was approximately 1.9g/fish/day with an FCR of 1.58:1. Biomass at harvest averaged 46 kg/m^3 with a maximum of 62 kg/m^3. They concluded hybrids can be grown to market size within 18 months at densities of 200 fish/m^3. Lower stocking densities exhibit slightly better growth rates, but less overall production. Stocking larger size fingerlings also appeared to be advantageous in cage culture.

Fingerlings averaging 20gm were stocked at densities of 10,000 and 15,000 fish/ha in freshwater ponds. Fish were fed to satiation 2-3 times per day with a commercial salmon diet and ponds aerated mechanically. Survival averaged 50% in the low density ponds and 93% in the high density ponds. Mean weight was 465 gm at the low density and 351 gm at the high density. FCR averaged 1.58:1 and standing crops were 2312 kg/ha and 4886 kg/ha in the low and high density ponds. Hybrids can be grown to market size in ponds in 15-18 months. Standing crops should be able to reach 5000 kg/ha which is considered to be a commercial density of channel catfish raised in ponds.

The potential for hybrid bass culture in cages or pens in Apalachicola Bay is excellent. Pond culture using fresh or brackish water also holds promise. Closing the reproductive cycle would allow fingerlings to be produced earlier in the year for stocking in April producing a marketable crop by December. Hybrids are not affected by winter temperatures in the bay, although growth rates are minimal. Limted marketing studies indicate the hybrid could sell as a food fish for $3-4 per lb live weight. A much more lucrative market may exist for raising stockers for a put and take freshwater recreational fishery, but would require a hatchery. The hybrid's status as a game fish is presently under revision to allow its culture and sale as a food fish. With such excellent market prices, the economic feasibility appears positive and a pilot study is highly recommended. The pilot study administered by ANES should demonstrate the latest culture techniques suitable to Apalachicola Bay and an economic profile to show the potential for investment in hybrid bass aquaculture.

G. Sturgeon

The Gulf of Mexico sturgeon (*Acipenser oxyrhynchus desotoi*) once ranged from Tampa Bay to the Mississippi River. Due to the sturgeon's anadromous behavior, large size, and reproductive requirements, populations are easily overfished. Today viable populations have only been observed in the Suwannee and Apalachicola Rivers and in Escambia Bay. Further fishing pressure and alterations to the sturgeon's spawning habitats have threatened these remaining populations. The only means to revive the population and redevelop a commercial fishery may be through hatchery production, stock replenishment and domestication of the Gulf of Mexico sturgeon.

Life history, especially the time spent in the ocean, along with reproductive behavior and larval development in rivers, is poorly known for the sturgeon. Wooley (1984) has recently completed a study on sturgeon movement and habitat in the Apalachicola River. Population size is estimated to be from 180-650 fish with an exploitation rate of 9.5%. This rate is considered to be high due to snatch hooking of fish in the river by recreational anglers and capture of sturgeon in trawls by both bay and gulf shrimpers. Captured sturgeon are seldom returned to the water. Sturgeon move to the mouth of the river in late March and early April. It is during this time period that commercial fishermen will catch sturgeon with a 9-10 inch stretch mesh nylon net, hung 35-45 meshes deep with no leads. Sturgeon 25 lbs. and over will get caught and roll up in the net where they can be removed unharmed, if so desired. Sturgeon can't always be fished during this period due to surges of river water which fishermen believe to be caused by operation of the dam. The surges may last up to two weeks by which time the fish have moved up river. To catch sturgeon the water must be dead (constant flow) like it always was before the dam.

By mid-April the sturgeon have moved up river and concentrate in the tailwaters of Jim Woodruff Lock and Dam (JWLD). The fish like deep holes (20 ft. or more) and swift current (2 ft/sec). Eggs ripen during May and June and this is the time of year to fish sturgeon for their roe. Spawning is believed to take place over hard bottoms on which the fertilized eggs adhere. Conditions for spawning are not well known, but are believed to be related to habitat (rock bottom), temperature (22-23°C), depth (greater than 20 ft), flow (588-846^{m3}/sec) and possibly other water quality factors (Wooley, 1984). At low velocities eggs will clump and be susceptible to fungus. At high velocities eggs will not adhere properly and be swept downstream. Almost nothing is known about larval development in rivers. Juveniles are believed to migrate downstream becoming imprinted to the chemosensory environment of their home rivers. Juveniles then feed in the bay or gulf and may join the annual return up river as early as age one (Huff). Commercial fishermen believe there is a large gar population in the river which successfully preys on the juvenile sturgeon keeping populations low.

Adults migrate back to the bay when temperatures fall below 18°C, especially during the last part of October and the first part of November. Many of the adults make a stop in the Brothers River, where several deep holes also exist, prior to migrating into salt water. Many small sturgeon (1/2 - 2 lbs.) are caught in the bay during November. Sturgeon then return to the gulf to overwinter. However, Wooley has shown that some sturgeon may extend their freshwater residency year round in the hole below JWLD.

Females are believed to sexually mature in 12 to 16 years and males in 9 to 12 years. Gulf sturgeon may live over 75 years and reach weights over 200 lbs. They are opportunistic feeders with benthic invertebrates, amphipods and crabs forming a significant portion of their diet in saltwater and plant material and detritus in freshwater. The change in diet results in a weight loss in freshwater and a weight gain in saltwater. The abundance of the exotic clam, *Corbicula fluminea*, in the Apalachicola River may be negatively affecting the sturgeon's feeding habits resulting in the freshwater weight loss (Wooley 1984).

The ACF river system once supported a healthy sturgeon fishery. Since the completion of JWLD, the fishery has steadily declined. The last documented sturgeon caught above JWLD was in

1961. While overfishing has played a role in the population decline, loss of habitat above JWLD may have effectively reduced the maximum standing crop the river may support. That is, sturgeon may have once spawned in places in the Chattahoochee and Flint Rivers which are no longer accessible and may only have a few remaining areas in the Apalachicola and Brothers Rivers in which to spawn. JWLD may also have a negative impact on spawning by altering normal flow conditions. The Russians have found that dams reduce the effectiveness of spawning activity by halting the spawning runs and causing the fish to increase its physical activity in response to varying flows which may result in stress and resportion of eggs. Thus, a number of factors, many of which are not well understood, affect the spawning of sturgeon, the hatching of the eggs, and post larval development. All these factors interact and play a role in survival and establishment of a healthy population. Whether the present population is at or near its maximum due to habitat loss or whether the river can support an increased population is not known. Enhancement of the population through culture techniques may provide a definitive answer and hopefully re-establish a healthy population.

Attempts to culture sturgeon were first tried nearly 100 years ago in response to a decline in the lake sturgeon (A. fulvescens) fishery in the Great Lakes. Lake sturgeon bring one of the highest prices of any freshwater fish in the U.S. or Canada and is valued not only for its flesh, but also for its roe which is made into caviar. Most caviar produced in the U.S.

today does not come from sturgeon, but rather from paddlefish (Polyodon spathula). The sturgeon fishery in the Apalachicola River never really developed a caviar market as there was only one person with the know-how to properly produce the caviar. In fact, dressed sturgeon presently only wholesales for $0.80 - $1.00 per lb. However, considering the potential markets for smoked sturgeon and caviar, its rapid growth rate, hardiness, and being a low trophic level feeder, sturgeon are well suited for culture. Both Japan and the Soviet Union have established aquaculture programs for sturgeon and basic hatchery methods are considered routine.

The Japanese have recorded growth to a size of 7-9 lbs. in as little as 15 months. U.S. researchers have induced spawning in both the white sturgeon (A. transmontanus) and Atlantic sturgeon (A. oxyrhynchus). Presently, a few commercial hatcheries in California are attempting to routinely reproduce and culture sturgeon. Their long term success has not yet been established.

The Russians culture five species of sturgeon at approximately twenty hatcheries releasing 100 million fingerlings a year. Recent advances in Russian culture techniques are not readily available in the literature with most work being published in the 60's and 70's. Translation and distribution of recent Soviet literature on methods used in that country would greatly help evaluate culture potential for species in the U.S. While the Russians have had some success with ripening adult sturgeon in captivity by mimicking natural conditions, the traditional method is to inject both sexes in the dorsal musculature or the peritoneal cavity with sturgeon pituitary and hold the fish in tanks until ripe. Ripe spawners are killed, gonads removed, eggs mixed with silt to reduce adhesiveness, mixed with sperm for 4-5 minutes, and placed in incubators for hatching. Depending upon the species and the temperature, hatching requires from 50 to 264 hours.

The Russians initially made the mistake, as did early American fish culturists, that fishery production could be materially increased by releasing fry in great numbers, an assumption that does not even hold true with respect to natural spawning (Bardach et al, 1972). Presently larvae are reared by stocking at densities of 5000 to 20000/m^2 in troughs filled with running water or in screen bottomed boxes floated in ponds. The fry are intensively fed for 10 days on daphnia and cladocerans and are then stocked in ponds at an average weight of 300 mg and an 80-90% survival rate. The fry are protected from light which seems to have an adverse effect on development. Fry are next cultured in ponds for 1-3 months on a mixed diet of Daphnia and oligocheate worms until a size of 75-100 mm (3-4 inches) is reached. Overall survival from egg to fingerling is 35-40%. The fingerlings are finally moved downstream to brackish water in special live boats and released. This greatly reduces losses to predation and at the same time allows the fingerlings to undergo imprinting as is the natural case in the wild. The Russians estimate 3% of the fingerlings survive the 8-15 years required to reach sexual maturity.

The Soviets have attempted some pond culture of sturgeon with some success. Work with a hybrid also appears promising; however, very little of this information is available in the literature. The Russians may have developed a technique to continually produce caviar. Adult tagged females are maintained in large lakes where they are captured each year during peak gonadal development, cut open to remove roughly three-quarters of one ripe ovary, and then sutured back up and released. The following year roe is removed from the opposite ovary. This technique produces roe without sacrificing the fish and should be studied for its applicability in this country.

Procedures for propagating and rearing sturgeon (*A. transmontanus*) fry have been described by Doroshov et. al. (1983) in California. Wild sturgeon are caught by hook and line in the Sacramento River and San Francisco Bay and transported to shore in a 500 l (132 gal.) tank. Live fish are hauled to the hatchery in a 1150 l (300 gal.) tank which may hold 4-7 fish for 3 hours. At the hatchery brood fish are placed in 10 m^3 (2642 gal.) tanks with a water flow of 50 l/min. at 13°C. Fish collected from brackish water are first acclimated to fresh water over a 24 hour period. Sex and gonad development are checked by taking the fish out of water except for a tube supplying water into the mouth, and making a midventral 2-3 cm incision anterior of the pelvic fins. The animal is sutured up and released within ten minutes with little stress. Ovulation was induced by injecting common carp or sturgeon pituitary intermuscularly at a dosage of 3-8 mg dried gland (diluted in 1 ml distilled water) per kg of body weight. Frequency of injections varies with the stage of oocyte development. The females are then placed in 1300 l (343 gal) circular tanks with 10-15 l/min flow at 12-15°C. Once ova are noticed in the bottom of the tank, the female is removed, ovulation verified, and the eggs removed by sacrificing the fish. Fecundity ranged from 7600 to 10900 eggs per kg of body weight (3450-4950 per lb). Sperm are collected by manually stripping hormone induced males and diluting 1:200 with water just prior to fertilization. Eggs were fertilized using the Russian method of rinsing and silting and placed in 18 l MacDonald incubators at a density of 400-800g of eggs (30,000-60,000 eggs) with a flow of 4-7 l/min at 14-16°C. Hatching begins during the seventh day of embryonic development and continues for up to 35 hours with success closely paralleling fertilization rate. The researchers have now developed a mechanical siltation and incubation unit which causes de-adhesion of eggs and allows newly hatched larvae to be carried directly to holding tanks (Monaco et al. 1983). This reduces manual labor as from 5 to 8 people are needed for a single spawning event.

Fry were reared in a variety of tank sizes using different foods and producing varied results. Live food consisted of <u>Moina</u>, <u>Tubifex</u> and <u>Artemia</u> in combination and alone while four artificial diets were also evaluated. Fish were fed to satiation. The majority of mortalities occurred between 17 and 37 days post hatch with the highest mortality observed in treatments with the longest delays before exogenous feeding. Best growth was obtained with live foods, however, semi-moist salmonid diets provided similar survival rates and eliminated the large mortalities associated with the transfer of fish from live food to artificial diets (Buddington et al. 1984). Survival was mixed as was feed conversion efficiency. Fingerling production was also varied, but some sturgeon have been raised in captivity to 2.5 lbs. in 15 months.

While sturgeon culture has promising potential, many problems need to be worked out before commercial feasibility is established. Major problems include the collection of broodstock, larval diets, disease susceptibility, water quality problems especially ability to tolerate low oxygen levels, and temperature sensitivity. Since sturgeon migrate from salt to fresh water to spawn, it is not known if captive sturgeon held in fresh water can breed without exposing them to saltwater between spawning seasons nor whether or not a captive fish will spawn every year. A cultured pond sturgeon produced for food may be possible within a few years, but a profitable caviar culture operation may require 15-20 years to develop. The Russians have shown that the wild fishery can be enhanced through the release of fingerlings and their work with extracting caviar from captive adults should be closely evaluated. The documentation of adult sturgeon overwintering in the Apalachicola River indicates sturgeon might be domesticated and cultured in fresh water.

Sturgeon steaks have been compared to sirloin and smoked sturgeon sells for as much as $30 a pound in California. Caviar from Great Lakes sturgeon wholesales for $30 per ounce. Caviar often retails for $75 - $100 per ounce. Tropical fish wholesalers in Florida purchase 3 to 6 inch fingerlings for $1.25 each f.o.b. Los Angeles and wholesale them for $2.50 each f.o.b. Tampa. The Gulf of Mexico sturgeon should be able to develop markets with similar prices. Capturing just the tropical fish trade in Florida might support operating expenses of a pilot scale hatchery. The State of Florida might be interested in purchasing fingerlings for public stockings if the fish can be bought for less than the cost of establishing a public hatchery.

One approach might be to incorporate sturgeon hatchery production into the multi-use facility described in the oyster plan. This could be economical, especially if a number of different species were to be spawned over time. If the facility is initially operated as a joint public/private venture, the governments role would be in research, development and transfer of technology and management to the cooperative. The cost of such a multi-use hatchery has not been itemized, but could easily exceed $100,000. The hatchery would require a number of tanks of different sizes, incubators, automatic feeders, a water system, an air system, equipment for culture of live foods, extensive plumbing, and a back-up power system and heaters. Fry, fingerling and brood ponds would be necessary as well as a live transport tank and truck. If a hatchery was built just for sturgeon, then it should realistically be built in Gadsden or Jackson County near JWLD or at a site near the Brothers River.

Another approach would be to develop a sturgeon grow out facility in freshwater ponds raising the fish to 2-3 lbs within 18 months. Ponds could utilize brackish water as well and net pen culture might also be attempted. Ponds could be located in Franklin County or in neighboring up-river counties. These approaches are recommended as a pilot or demonstration project for full biological and economic evaluation. Production of fingerlings and release into the Apalachicola system may eventually support a viable fishery again if habitat is sufficient or if the fish are aided in their migrations to pass through the dam. After the fishery is established, a modification of the Russian caviar extraction might be employed by tagging fish and leasing commercial fishermen the right to capture, remove roe, and release the fish year after year on their way to spawn. Such a fishery would be highly profitable as equipment would be limited to a boat and nets with no support facilities.

Development of a sturgeon aquaculture program in the river and bay holds great potential. Programs in Russia, South Carolina, and California should be carefully studied and monitored, prior to testing the feasibility in this area. The program should be tied into the multi-use facility and initially managed by the State via the ANES.

H. Penaeid Shrimp

Shrimp are the most valuable fishery in the U. S. and are no exception in Apalachicola Bay. Landings for 1981 were 4,787,717 lbs. with a value of $7,983,247 and for 1982 3,047,102 lbs valued at $6,399,351 (NMFS). However, the shrimp were caught both in the bay and the gulf and as such cannot be directly compared economically with species harvested exclusively from the bay. All three species of shrimp do utilize the estuary as a nursery grounds and therefore are dependent on the continued integrity of the resource for their survival.

White (Penaeus setiferus), pink (P. duorarum), and brown (P. aztecus) shrimp are the three commercially important species which utilize the nursery at different times of the year and as a result, are harvested at different times of the year. Basically, all three shrimp spawn in the gulf in full strength seawater. The eggs hatch and are carried by currents for two to three weeks as they transform into post larvae (nauplius, protozoea, mysis, and post mysis) where the few that survive (9.05% from spawned eggs - Kurata 1981) reach the estuary. The juveniles feed, grow and mature in the estuaries. The importance of the estuarine habitat to the life cycle of shrimp cannot be overstated. As nursery habitat is destroyed through pollution or development, total shrimp populations will be reduced. After spending 3-4 months on the nursery grounds, the adolescent shrimp leave the nursery, returning to the gulf to mature and reproduce. Most shrimp do not live more than a year due to intense predation by a number of organisms and fishing pressure exerted by man. However, it is incorrect to say that shrimp only live one year.

White shrimp spawn from April through August in 4 to 17 fathoms (24-102 feet) and a female may lay between 500,000 and 1,000,000 eggs. They are primarily distributed from Texas to Carrabelle. They arrive in the nursery beginning in the spring where they may increase their weight more than four times a month. They migrate from the nursery to the gulf during the fall months when waters begin to cool. Some of the smaller whites will overwinter in the estuary, but growth will be retarded by the lower temperatures. Whites are the predominant species in Apalachicola Bay and particularly like to seek sanctuary in East Bay and St. Vincent Sound. They are principally fished in the bay from July through November (70 plus count) and occasionally caught in the passes in April and May (21-30 count) when currents bring them into the bay from their spawning grounds.

Brown shrimp, locally referred to as hobos, spawn in the winter farther offshore than whites and move into the nursery during late winter or early spring to grow. Browns leave the bay primarily in June and July and are heavily fished during the summer months. Adults are nocturnal, burying themselves during the day and feeding at night. Juveniles in the nursery do not seem to be as strongly nocturnal and are often fished in the bay both day and night.

Pink shrimp or hoppers are found in all coastal waters of Florida. Pinks spawn year round in South Florida with principal spawning in the panhandle occurring in the fall. Pinks enter the nursery during early winter and exit during the late spring. Pinks are believed to hibernate in bottom estuarine muds during prolonged periods of cold weather. This hibernation, coupled with the fact that fish tend to leave the estuary during cold weather, results in a significant reduction in predation producing a bumper spring crop. This is a theory postulated by Ingle which has never been experimentally proven. Pinks tend to prefer the higher salinity waters found at the east and west end of the bay.

The major question concerning the shrimp fishery in the bay is whether to have shrimping in the bay or whether to close off the bay to shrimping and allow the bay to be used exclusively as a nursery grounds. The argument for closing the bay to shrimping is primarily biological in that the nursery shouldn't be exploited. After using the nursery to grow, the shrimp move out of the estuary where they are captured. The shrimp are bigger, worth more money, and the season will last longer. By harvesting small shrimp from the nursery, the shrimp aren't allowed to reach maturity and less are recruited into the gulf shrimpery. Since most of the bay shrimp are not yet mature, their diurnal migration habits have not been perfected. Thus, small shrimp, such as whites, will be captured at night while fishing for larger brown shrimp during the summer. The biological concern is that the fishery may be depleted by overfishing juveniles in the bay. Another concern is that bay shrimping damages oyster bars and that many immature fish, especially flounder and trout, are caught inadvertantly and killed in the shrimp trawl. Closing all or a portion of the bay to shrimping would then enhance the growth and survival of a number of organisms dependent upon the nursery during a critical stage of their development.

Bay shrimpers have counter arguments which are primarily based on economics. While bay shrimpers do not fully understand the biology, life cycles, and migrations of the three species of shrimp, they do know the times of year the shrimp can be harvested in the bay, the corresponding size of these shrimp, and the potential price. The driving force behind any business is profit. Bay shrimpers will only shrimp when there is sufficient shrimp to be caught to be profitable. If the shrimp aren't around, then they won't work, as fishing becomes too costly. Thus, they believe economics protects the resource by preventing over shrimping and allowing the resource to recover.

Entering the bay shrimping business is not nearly as capital intensive as gulf shrimping. Overhead and depreciation are much less since a smaller vessel is used and the range of fishing effort is limited to the bay. Harvested bay shrimp are returned to the docks the same day they are caught. Shrimp can be caught in the bay year round; however, fishing usually slacks off during cold winters. Larger whites are usually caught just inside the passes in March and April, browns from May through July, smaller whites from August to December and a few pinks during the winter. The average bay shrimper fishes approximately 100 days per year with an average catch of 200-300 lbs. per day. This is considered an adequate living if prices remain stable. However, fishing is a hit or miss proposition and this is why shrimpers believe the economics of fishing protect the resource. Weather is a big factor and bad weather can ruin good shrimping. Too much rainfall or fresh water entering the estuary from the river seems to cause white and brown shrimp to leave the bay. Shrimpers claim there are just as many shrimp in the bay today as there were 20 years ago, just more shrimpers.

The bottom line to shrimpers is profit. Some segments of the industry believe the shrimp in the bay must be continually cropped to maintain prices. That is, the higher the production, the greater is the amount of shrimp harvested which results in a price drop and the smaller the population of shrimp in the bay, the higher the price. The shrimpers contend that shrimp left to overwinter or migrate out of the bay and return will just produce a bunch of large shrimp which will lower prices. They also contend that many of the small shrimp they harvest will never reach a larger size due to predation. They believe the white shrimp will never be depleted and that East Bay is sufficient nursery grounds to maintain a healthy population. These shrimpers believe they are substantiated by the fact they continue to catch shrimp year after year. However, this could also be interpreted as being somewhat short sighted as a fishery may fail in any given year for a number of reasons. A fisheries management plan for the bay cannot adopt this attitude, but must instead develop methodologies to protect and enhance the fishery.

During the 1920's, Apalachicola Bay was in its natural condition and produced abundant harvests of oysters, crabs and fish. Although the bay was plentiful with shrimp, none were harvested as dealers would not buy what they considered to be undersized shrimp. Bay shrimping began in the late 1930's when a market developed for small shrimp. Some locals believe that by 1960, a definite downward trend could be seen in oyster production due to the bay shrimping. During the 1960's a portion of the bay presently bounded by the Intercoastal Waterway and the two bridges, was closed off to shrimping for five years. The oyster bars benefitted tremendously, as did the shrimp fishery. Small shrimp in the newly closed nursery area were protected and were not captured until they grew larger and moved outside the closed area. The season lasted longer and production increased. Politics reopened the area and within three days of intense fishing, the shrimp population in the area was nearly depleted. Counts dropped from 60 to 96 per lb and many small fishes were caught and killed in the nets. Gradually production outside the area began to decrease as well, due to a lower amount of shrimp coming out of the East Bay nursery area. Some shrimping elements believe they are working harder and catching less shrimp. Depletion of the bay shrimp fishery has been contended by many, but there is not enough evidence to say this is certain. All this points to a need to re-evaluate the closing off of portions of the bay to shrimping or limiting the shrimping season so that the nursery will be expanded and small shrimp protected during their period of most rapid growth. One management approach which was originally proposed by Ingle over 20 years ago and later aggressively pushed for by George Kirvin, but which has never received critical evaluation from a fisheries biology or management viewpoint may be called the Ingle plan. The plan is shown in Figure 2 and basically divides the bay into a northern half for use as a nursery and oyster grounds, and a southern half to be used for shrimping and fishing. Shrimping in the southern half would only occur when sampling determined the shrimp to be of good size. The Ingle plan would also protect spawning grounds in the gulf during April, May and June when white shrimp are known to spawn.

The bay shrimpery should be carefully assessed to determine its future viability. If a decline or depletion of the fishery is predicted, then careful consideration should be given to the Ingle plan or a similar plan. The plan, if implemented, should be carefully monitored to assess its full effects on the shrimp fishery in and outside of Apalachicola Bay. Another alternative is to enhance the fishery or supplement the fishery through mariculture.

In 1983, over one half of all shrimp consumed in this country were imported. Shrimp consumption is projected to increase while

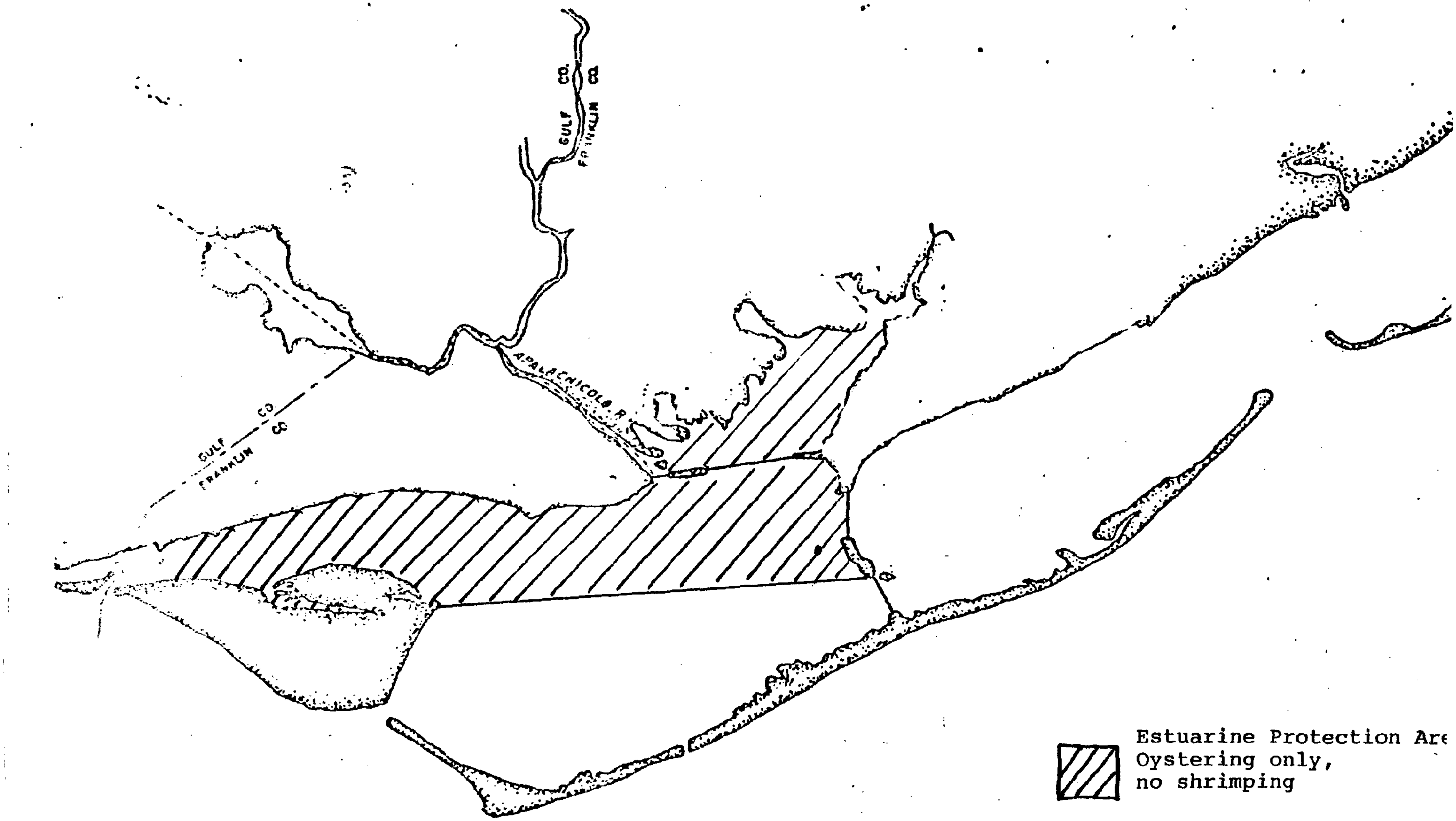

Figure 2
INGLE PLAN

harvests from natural stocks are approaching their maximum sustainable yield. Prices will continue to rise due to increased demand, limited supply and escalating cost of fuel (NADP, 1983). Shrimp farming will play an increasingly important role in supplying shrimp for the U. S. market.

Shrimp culture can produce food for human consumption, bait for recreation, and possibly seedstock for a fishery enhancement program. Shrimp culture consists of a reproduction phase, a hatchery phase, and final grow out. A predictable and consistant source of seedstock (larvae) has been a major constraint to shrimp culture. Controlling the maturation process has been achieved for some species by manipulating light intensity (20-60%), photoperiod (14 hrs light, 10 hrs dark), and temperature (22-28°C). Unilateral eyestalk abaltion has also been used to enhance spawning. Control of reproduction to produce seed year round is a high priority. Recent improvements in technology, including artificial insemination and the production of hybrids may remove the barriers from the reproduction phase and increase the feasibility of commercial production. Commercial production requires survival to be 20% or more. Shrimp larvae have also been produced from sourcing, which is the capture of mature females in the ocean and subsequent spawning in captivity. Both the white and brown shrimp have reproduced in captivity, as well as many other species.

The hatchery phase rears newly matched Nauplius larvae for 10 to 14 days to produce what is known as a postlarvae. Postlarvae are then reared for an additional 5 to 10 days prior to stocking for final growout. While the technology for the hatchery phase is considered adequate to support a commercial operation, problems which must be dealt with include the percent survival, variability in different batches of offspring, control of water quality, foods and feeding schedules for larval rearing, and disease-diagnosis and control in the hatchery.

Post larvae may be stocked in ponds, tanks or raceways for final growout. Food sized shrimp require 3 to 6 months growout to produce 15 to 40 count shrimp, while bait shrimp require 1.5 to 2.5 months growout time to produce 60 to 100 count shrimp (Lawrence 1983). Pond culture is the most common form of growout and can be accomplished in a two or three phase system where postlarvae intensively stocked in a small pond are thinned and moved into successively larger ponds as the organisms grow. Production can range from 500 to 2000 lbs/acre depending upon the level of management, the use of feed and fertilizer, water quality and exchange, and optimum stocking densities. Estuarine water can be used in culture ponds. Temperatures should be between 18 and 31°C and salinities 10 to 40 ppt for good growout. Pond survival has varied from 40 to 90% in different culture trials. A recent study by Tatum in Alabama showed that shrimp trawlers used $35 of diesel fuel for every 100 lbs of shrimp caught, while pond culture of shrimp only required $12 of diesel fuel for every 100 lbs of shrimp produced, making pond culture more energy efficient than the shrimp fishery.

Shrimp may also be cultured in semi-closed or closed recirculating intensive systems. These systems require more capital, a higher level of engineering, more management, and more energy. A few commercial ventures are reported to be nearing success with estimated production of a minimum of 50,000 lbs/acre/year valued at $125,000/acres (NADP, 1983). In Taiwan, shrimp are cultured intensively in 0.5 acre ponds with continuous aeration and water circulation producing up to 3000 lbs. per half acre.

Another method of shrimp culture presently being evaluated in South Carolina should be closely monitored for potential application in Florida. Old salt water impoundments originally constructed to grow rice more than 100 years ago are being assessed for shrimp culture. The impounded marshes perform the same function as an unimpounded marsh, except that the inflow and outflow of water can be controlled. Water level and control are tied to the tidal cycle. The impoundments are drained at low tide and cleaned of existing fish. The ponds are then flooded for 7 to 10 days, raising the water level each day, and finally maintaining the water level at a minimum of 15 inches. Many ponds are kept at 24 inches depth to protect plants on which water fowl feed. Most ponds have a dual use of water fowl management and shrimp culture. Post larvae are then stocked at high densities in the pond and left alone to grow. Four to five months later the ponds are drained and shrimp harvested. So far yields have ranged from 30 to 1400 lbs. per acre. In addition, other fish and blue crabs may be harvested. One 15 acre pond produced 854 lbs. of white shrimp, 488 lbs. of fish and 50 lbs. of crab worth nearly $3600. Not much is known about managing such impoundments to increase yields. However, two commercial ventures are in operation and if successful, could have wide spread application in other coastal areas.

A final mariculture tool of potential consideration is the releasing of hatchery reared fry into the estuary. This is a very controversial subject area, but there is some limited evidence to support such a program if the releasing is well organized according to sound techniques to obtain positive results. The Japanese have had some preliminary success to date (Kurata 1981) and a recent highly sophisticated tagging and release program is underway in Kuwait. The Japanese, using Kuruma shrimp (*P. japonicus*), identified three successive periods of mortality upon release of fry. Hatchery reared shrimp undergo a severe initial mortality during the first 24 hours after release, a variable intermediate mortality, and a stable low level mortality from 3cm length to commercial size. The Japanese believe at 3cm body length the kuruma shrimp acquire the general behavior of adults and mortality closely parallels that normally found in the wild. Mortality was found to be caused primarily by small fishes; however, crowded conditions or insufficient food will cause the fry to disperse from the release area into more open areas where survival is much less. The fitness of fry was determined by evaluating the habitat, survival potential, and behavior of shrimp. The results concluded that benthic juveniles (1cm) were the best stage for releasing if the fry are adequately protected against adverse conditions until attaining an average length of 3cm.

The most favorable release sites were found to be where fry settle on intertidal areas lying between the mean low water level of neap tides and mean sea level where the substrate is exposed for up to 12 hours during low tides and covered by a few feet of water at high tide (Kurata 1981). The Japanese construct man-made nurseries called artificial tidelands for release of shrimp. The tidelands enhance settlement of shrimp fry and attempt to keep predatory fish away during low tides by manipulating physical conditions such as elevation, wave action, currents, depth, substrate, and water supply. The artificial tidelands harbor and nurse the fry until they reach 3cm and gradually move out of the tidelands. A stocking figure which includes mortality is 5 million fry released onto 50ha (123.5 acres) at an average density of 100 fry/m^2 (2.6g/m^2). However, as the fry grow they require more food and thus room, so an additional 450ha (1111.5 acres) of nursery area is required to keep the intermediate mortality within the expected range. A higher elevation was found to be more beneficial in settling higher numbers of fry and keeping predatory fish out of the nursery area. A supplemental supply of water is necessary to maintain water quality. Waves and currents are controlled with a breakwater.

A great deal of difficulty exists in proving conclusively the effect of fry release on the yield of commercial catches due to the role of natural fluctuations in shrimp populations. Annual overall shrimp landings, once depressed, have increased since the initiation of a fry release program in the Seto Island Sea. However, the same situation might occur in a natural fishery. Size frequency distributions at weekly intervals between wild and released shrimp were used by the Japanese to estimate a recovery of 5-8% of hatchery released shrimp. If the artificial tideland can be used at least six times a year, a profitable cost/benefit ratio can be attained. Additional work promoting production of food organisms on the tideland and displacing all the larger juveniles prior to the release of a new batch of fry will improve the overall feasibility of a release program. However, much more data will be required before this technique can be adequately proven.

A second technique of shrimp enhancement is to release the fry in an enclosure surrounded by a net fence. Continental Fisheries, LTD (formerly Marifarms) in Panama City attempted this technique from 1971-74 in West Bay (Kittaka 1981). The total area used varied from 1000 to 1700 acres and was divided into a pen (0.0625 inch mesh), a nursery (0.5 inch mesh), and a growing (0.75 inch mesh) area. Post larval white, brown and pink shrimp were released into the pen at 0.3g. After the shrimp were grown to a sufficient size, the pen was opened and the shrimp released into the nursery area until they reached 1.1g mean weight. After one to two more months the shrimp were released into the grow out area. An attempt to remove both predatory and non-predatory fish which compete for food was made with mixed results. Survival rates immediately after release were 27% for browns, 87% for whites and 55% for pinks. The recovery rates ranged from 2-13%. The commercial success was never demonstrated and failure was largely attributed to escape from the netted areas. However, during one of the test years an above average harvest of over 100,000 lbs of white shrimp were caught by commercial shrimpers in the bay system indicating some support for this type of release program. On the other hand, recovery rates of shrimp released into large impounded ponds along the shore of West Bay ranged from 27-51% which was largely attributed to the absence of predators.

A release program for white shrimp in Apalachicola Bay might be feasible if a number of questions can be answered. A small scale demonstration using net enclosures could be attempted at reasonable cost and with little environmental impact. An artificial tideland would cost more money and significantly alter the environment in creating this new habitat, but if regularly used under appropriate conditions as in Japan, might be successful. Research would need to be performed on the site to determine appropriate substrate, tidal cycles, elevation, water quality, food supply, and control of predators. Behavior and survival of white shrimp would need further study to estimate the best stage or size for release and the size at which white shrimp become strong enough to reasonably protect themselves in the natural environment. Predatory fishes of shrimp at different life stages need to be identified and the artificial tideland manipulated to eliminate them. A sophisticated tagging program would have to be designed to evaluate the merits of such a program. Finally, the costs of such a program would have to be compared to the added benefits showing up in commercial catches and compared to the costs and returns of culturing shrimp to market size in ponds. Pond culture may then prove to be more cost efficient in the long term.

There are many technical areas of shrimp culture which can be improved through research. More needs to be known about natural reproduction and nutritional requirements of different species even though much has already been discovered and is presently being applied. Comparative studies on growth and behavior of different species under different culture conditions are needed. Least cost diets for specific species need to be developed for each stage of growth and for different culture systems. More information is also needed on predation and control of diseases. A lack of sites and competition for available sites has constrained development as has the complexity of the permitting process. Inclusion of mariculture into coastal zone planning and establishing a lead agency to assist in developing the industry could minimize these constraints.

Several economic estimations for shrimp culture have been generated by the shrimp research group at Texas A & M (Johns et al., 1981; 1983 Pardy et al 1983). One of their examples is shown in Table 3. Net profits can range from $120 up to $2000 per acre depending upon the success of the operation. Realistic cost and profit information is needed by lending institutions in order to adequately assess loan applications.

The potential for shrimp culture in the Apalachicola Bay area is good. Available sites for ponds exist along St. Vincent Sound. Processors, labor and markets are already in existence. A commercial source of white shrimp post larvae exists in Panama City. The only factor absent is the interest to develop a culture operation. Expansion into a hatchery phase could be part of the multi-use facility described in the oyster plan. Production of bait shrimp requires less time and costs less than production of food sized shrimp, yet has a producer value equal to that of food sized shrimp. Bait shrimp, especially whites, are in demand throughout the coastal area. The culture of either bait or food sized shrimp would benefit the fishery resources of Apalachicola Bay by providing a supplemental source of shrimp for processors, providing an economic alternative for financially stressed bay shrimpers, and by relieving some of the fishing pressure being exerted on the nursery. A combination of shrimp culture and bay management (such as the Ingle plan) are recommended to insure the long term viability of the shrimp industry in Apalachicola Bay.

Table 2
Penaeid Shrimp Culture Production Costs

ASSUMPTIONS:

	Best Case	Expected Case	Least Case
Number of acres	250	250	250
Production (heads-off) Pounds/acre	1055	931	780
Days in pond	210	196	182
Size of shrimp (lb) at harvest	0.071	0.062	0.051
Price/lb (heads-off)	$ 5.43	$ 4.80	$ 4.80
Initial density/acre	40,000	40,000	40,000
Harvest density/acre	22,302	22,384	22,716
Percent survival	55.7	55.9	56.8

Source: Johns, et al. (1983)

Table 3
Panaeid Shrimp Culture Production Costs

PROJECTIONS:	Best Case	Expected Case	Least Case
Gross revenue	$1,435,023	$1,119,848	$ 937,846
<u>Variable costs</u>			
Seedstock	149,685	149,685	149,685
Feed	269,812	234,301	205,287
Labor	57,60	56,456	55,652
Other	73,285	73,157	73,033
TOTAL	$ 550,042	$ 513,599	$ 587,657
<u>Fixed costs</u>			
Salaries	43,200	43,200	43,200
Depreciation	86,254	86,254	86,254
Interest	267,480	267,302	266,626
Other	20,268	20,268	20,267
TOTAL FIXED COSTS	$ 417,201	$ 417,023	$ 416,347
TOTAL COST	$ 967,243	$ 930,622	$ 900,347
Net return (before tax)	$ 467,780	$ 189,226	$ 37,842
Federal income tax	$ 215,180	$ 87,044	$ 7,568
Net return (after tax)	$ 252,600	$ 102,182	$ 30,274
Required return to other equity	$ 88,101	$ 88,101	$ 88,101
Economic profit	$ 164,499	$ 14,081	$ -57,827
Break-even price/lb	$ 3.66	$ 3.99	$ 4.60
Break-even production (lb)	$ 36,504	$ 35,121	$ 33,965
Net profit/acre	$1,495.34	$ 408.72	$ 121.10

Source: Johns, et al. (1983)

I. Baitfish Culture

The culture of baitfish began in the early 1900's; however, significant progress and expansion was not attained until the 1950's and 1960's. Most baitfish are cultured in freshwater and as a result most available information is derived from the freshwater baitfish industry. Saltwater anglers enjoy fishing with live bait, most of which is trapped in shallow estuarine areas. The major species sold as bait along the northern Gulf of Mexico are penaeid shrimp (*Penaeus* spp) and the Gulf killifish (*fundulus grandis*). Killifish are commonly known as bull minnows and are used to catch red drum, spotted seatrout, and flounder. A 2 to 3 inch bull minnow is considered desirable bait. Due to increased recreational fishing, and a limited natural spawning season, supplies of bull minnows have fallen way short of demand and this has resulted in research aimed at producing bull minnows commercially.

The majority of research on commercial culture of bull minnows has been performed by researchers at the Claude Peteet Mariculture Center in Alabama (Tatum 1979, 1982; Trimble 1981). Culture occurs in a three phase pond technique consisting of a brood pond phase, hatching pond phase, and grow-out pond phase. This procedure results in high survival of disease-free eggs and fry and producing multiple crops of bull minnows for the live bait market. While further research is required, present results are sufficient to recommend commercial culture.

Ponds may average 0.2 acres and 5 ft. in depth. Brood fish averaged 9.6 gm and were stocked at approximatly 10,000 fish/acre and a ratio of two females to one male. Ponds were periodically fertilized with chicken manure at 250 lbs/ac and oiled with a mixture of oil and diesel fuel (1 qt. oil to 9 qts. diesel fuel/surface acre) to prevent predation by insects. Spawning begins in March (20°C) and gradually decreases until it ceases in August. Spanish moss spawning mats are placed around the edges of the brood ponds and the egg-laden mats are removed every 7-13 days and transferred to hatching ponds. Fish then hatch and grow in these ponds until they reach an average of 0.5 gm where they are then transferred to grow out ponds. Newly hatched fry may develop on natural foods available in the fertilized ponds or supplemented with commercially available minnow chow. Grow out ponds may be stocked at densities up to 100,000 fish/acre (roughly 110 lbs/ac). Fish are fed twice daily at 10% of the total biomass. Minnow chows produce lower yields than trout chows, but give higher returns over costs. Ponds are harvested at 55 day intervals when fish average 2-5 inches and 2-5 gm in weight. Feed conversion averaged 2.4:1 and survival was usually greater than 90%. Three successive crops can be produced with a combined annual production of 1770 lbs/ac. The operation can produce over 600,000 marketable size fish per acre. Since bull minnows are sold by the dozen, gross revenue can exceed $45,000 per acre (Tatum).

Research needs include much work in genetics and reproduction to spawn bull minnows year round and select fast growing, disease resistant strains. Most knowledge about nutrition has been borrowed from trout research and specific information related to baitfish is lacking. Baitfish ponds may produce many undesirable algae and aquatic plants which are not easily controlled without killing the fish or resulting in oxygen depletion. Control of predation by a number of organisms is badly needed. Access to suitable coastal sites is often a problem too.

Bull minnows are seldom used as bait in Apalachicola River and Bay primarily because they are unavailable. They are, therefore, considered an untested bait. White shrimp in the 40-50 count range are the preferred bait. Dead shrimp are purchased from bay shrimpers. Live shrimp are usually caught by fish camp operators or individuals who specialize in live bait capture. Boats must be equipped with live wells and tows must be slow, lasting not more than ten minutes to insure the shrimp are captured alive. Anglers purchase the live shrimp for $2.25 per dozen; however, fish camp operators don't believe there is much profit in bait shrimping, but rather it is a necessary part of their overall operation. The camp must own and operate a boat which includes paying a crew, and shrimp are not always caught. The cost of such an operation is not known, but should be determined and compared with pond bait shrimp culture in Alabama. If the costs are significantly lower, a bait shrimp operation could be started to steadily supply the recreation market throughout its entire season.

The Apalachicola River and Bay system supports a large recreational industry. Production of killifish and shrimp for saltwater fishing and minnows, elvers, shiners and crawfish for freshwater fishing could be a profitable business. Brackish water sites are not as available as freshwater sites. Research in Alabama should be monitored and the feasibility of marketing baitfish be determined prior to the development in Franklin County. More information needs to be collected from recreational fishermen angling in the bay as to what species are biting, where they are hitting, and what types of bait are catching the fish. A demonstration of both shrimp and bull minnows could be evaluated through the Sanctuary research and education program.

J. Other Species

Many other species naturally occurring in the bay and/or gulf may have culture potential for Apalachicola Bay. Full assessments of these species were not made due to a lack of culture information, priority preference of species already discussed, and time constraints. However, some of these species are worth mentioning for future consideration.

Black or striped mullet (*Mugil cephalus*) support the largest marine finfish fishery in Apalachicola Bay. Landings in 1982 were over 652,000 lbs. (NMFS). Landings have historically been much higher and the mullet fishery may be experiencing an overfishing problem. Although they spawn in the fall in oceanic waters, mullet spend most of their lives in estuaries where they feed on benthic detritus, diatoms and algae. As primary consumers they have excellent potential as a mariculture species, as they can be produced in large volume at low cost. In fact, mullet are both monocultured and polycultured in brackish and fresh water ponds in many countries, including India, Indonesia, Taiwan, China, Hong Kong, Italy and Israel. However, their low price and poor marketability to American consumers restrict their development as a mariculture candidate. They might be stocked in low densities in a polyculture with another more valuable species in a net-pen situation. Researchers in Texas have used this technique to increase overall productivity, maintain better water quality, and reduce fouling.

Flounders (Paralichthys spp) once supported an active fishery in Apalachicola Bay and are, in fact, a commercially important species landed in Franklin County representing 94,841 lbs worth $49,971 in 1982 (NMFS). Many local residents believe bay shrimping caused the decline in the flounder fishery in the bay as many juvenile flounder get caught in the shrimp trawl and never reach harvest size. Flatfishes, including flounder, plaice, sole, halibut and turbot were among the first marine fishes to be experimentally cultured. Flatfish larvae were stocked in large numbers at the turn of the century primarily in the Irish Sea and accomplished nothing other than to provide a free meal for various predators (Bardach 1972). Flatfish are now routinely spawned and cultured in Great Britain in enclosed sea lochs, net cages, and tanks and raceways using heated power plant effluent.

Winter and smooth flounder have been cultured in the northeastern U.S. Larval rearing, feed formulations and diseases are presently the major biological constraints to successful culture. Development of more oyster reefs and the prohibiting of bay shrimping over these reefs may be all that is needed to restore a flounder fishery in Apalachicola Bay.

Blue crabs (*Callinectes sapidus*) are a commercially important species harvested out of Apalachicola Bay. In 1982, 982,654 lbs valued at $238,379 were landed in Franklin County (NMFS). Wakulla County traditionally has the highest landings in the state. The waters off of Franklin and Wakulla Counties are considered to be important spawning grounds for blue crabs which migrate up the west coast of Florida from as far south as Charlotte Harbor. The Apalachicola River may act as both a window inhibiting further westward migrations and as a possible larval transport mechanism, for reaching offshore waters more suitable for larval growth and development. Researchers at the University of Miami reared blue crabs from egg to market size in 3-4 months from hatching, but survival was very poor. Temperature and salinity factors appear to be critical in larval development. Research has not progressed, most likely due to the present low price received per organism and competition from the commercial fishery. Production of soft crabs has considerably more profit potential and in fact, is practiced to a limited extent in Franklin County.

Mussels in Apalachicola Bay are small and considered to be a competitor for space with oysters. However, a much larger mussel has been reported to be found in certain parts of the bay and is reported to have good taste, but does not have the characteristic reddish-pink color when steamed. Techniques for mussel culture are well known and good markets exist. A good research or thesis project would be to seek out this mussel, study its biology and test its potential for culture.

Rudloe (1983) has performed some preliminary work with the culture of the slipper lobster (Scyllarides nodifera) in tanks designed to resemble a natural looking habitat. The organisms were captured at the post larval or puerulus stage as they moved inshore and reared to 30 cm in 16-18 months at 20-26°C and 30-35 ppt. They were fed mussels (Modiolus sp) at 1.26 mussels/day/lobster, or clams (Rangia sp) at 1 clam/day/lobster and were fairly non-aggressive towards each other. Slipper lobster have good consumer acceptance and may have a future potential cultured in cages located in higher salinity waters or in intensive tank culture.

Culture methods for the hard clam (Mercenaria mercenario) and scallop (Argopecten irradians) exist, but these organisms require higher salinities than are normally found in Apalachicola Bay. Limited work has also been done with the commercially important stone crab (Menippe mercenaria), but presently the commercial fishery would out compete a cultured crab in the marketplace as the crab is released after the claws are removed. Research in Texas with Atlantic croaker (Micropogonias undulatus) resulted in poor survival in ponds and a negative assessment to their potential as a mariculture species. Preliminary work with the dolphin (*Coryphaena hippurus*) is promising as these fish readily spawn and reach market size in as little as three months. Larval rearing and cost effective feeds are currently constraints; however, once the problems are solved, two crops per year might be cultured in cages in Apalachicola Bay if fluctuating salinities are not a constraint. Gafftopsail catfish (*Bagre marinus*) may have culture potential, but have never been investigated. A commercial fisherman once captured a school of these fish as they entered the bay on the first full moon before Easter, herded the school into Nicks Hole where he fenced them off, and then fed, harvested and sold the catfish over a two month period.

K. Species Assessment Summary

A great deal of research has been accomplished on culturing marine finfishes, but much more research followed by pilot demonstrations and economic analysis, are necessary prior to commercial development of most of the species assessed in this section. The major biotechnical constraints in Apalachicola Bay are temperature and salinity. Seasonal changes in temperature normally require some species to leave the estuary for warmer waters. Confined organisms cannot leave and will either cease growing, die or must be artificially maintained. Rapidly fluctuating salinities cannot be tolerated by some species and the generally lower salinities found in the bay are prohibitive to others. However, not all species candidates are limited by these constraints as many can be overwintered and acclimated to these physical changes. Marine finfish nearly all hatch out at a very small size which means they have very tiny mouths. Initial feeding of most of these fry is presently a constraint or the missing link in closing the culture cycle. Overall, Apalachicola Bay offers excellent water quality and mariculture potential.

Baitfish, shrimp, hybrid bass, red drum and sturgeon appear to be the most promising species for culture in ponds or cages. Stock enhancement should presently be limited to recreational species as the recreation industry is the only user segment of the fishery which can support such a program. Applied research through demonstration of a species potential in the bay or on shore in upland sites should be coordinated through the Estuarine Sanctuary's research and education program.

The species with the greatest mariculture potential and with the greatest economic impact on Franklin County was not assessed in this section. That species is the oyster and a thorough assessment is presented in the following section.

VII. OYSTER SPECIES PLAN ASSESSMENT

The American oyster (Crassostrea virginica) is considered the most commercially important resource in Apalachicola Bay. The foundation of the local economy, employment and social structure is based on the oyster. This in turn has led to increased pressure on the resource resulting in a declining fishery over the past few years. The decline has been due to a combination of factors including overfishing, inadequate enforcement of laws, social conflict and policies, environmental stresses from sewage, runoff, urban development, and manmade bay alternations, and natural mortality. The net results are a faltering economy and an ill managed resource. The solution is to improve resource management through a cooperative effort combining biological information, economic analysis, education, and awareness of sociological impact. This necessitates improved communication among workers and dealers in the industry, other residents of the county, and representatives of government.

A. Industry Status

Although record harvests were achieved from 1978 through 1981, many local industry members believe the Bay's fisheries, especially oysters, have been declining since 1970. During this period many Virginia companies came down and purchased anything which could be tonged (shell, seed and oysters) to replant in Chesapeake Bay. There were no laws to protect the resource and many locals believe this was the beginning of a downward trend.

At the time, the county reportedly produced 20,000 gallons per day of shucked oysters. However, today overfishing of oysters is the major problem affecting the productivity of the bay. The number of oyster tongers has increased from less than 500 in 1970 to nearly 1150 in 1984 while productive oyster acreage has remained roughly the same. This means there are more tongers spending more time looking for the same amount of legal sized (3 inches or larger) oysters. This increased pressure results in a reduced amount of legal sized oysters and an increased amount of undersized oysters harvested from the bay. It is somewhat analogous to a lawn which is repeatedly mowed without allowing any time for the grass to grow. The need then is for increased production through better management.

In 1983, the Department of Natural Resources reported a total of 4,942,000 lbs (450,514 gallons) of shucked oyster meats produced from Apalachicola Bay. The oysters were processed by 71 dealers and had a total value of $4,126,000. This does not include oysters trucked in from other Gulf states and processed in Apalachicola. The poundage roughly equates to 540,740 bushels of oysters or 470 bu per permit per year. A tonger could easily harvest this amount in 20-30 working days. Since 470 bushels are not enough from which to earn a living, most permitted tongers would seem to only work part time. Alternatively, many oysters reportedly are taken from the bay and leave the county without being recorded by the DNR which further contributes to overfishing. Overall there doesn't seem to be enough oysters to satisfy the yearly income needs of all those permitted.

Rockwood (1973) made a comprehensive analysis and recommended a management program for the Apalachicola oyster industry. Few of his recommendations have been enacted, yet nearly all of his conclusions remain valid today. The DNR, Florida Sea Grant, and the Apalachicola National Estuarine Sanctuary have sponsored several oyster conferences and workshops for oystermen, shuckers and dealers to agree on appropriate management techniques for the resource. Until this can be accomplished, the resource is expected to continue to decline.

Problems in Apalachicola Bay came to a head during the spring of 1984 when the bay was closed for nearly a month. Harvesters were hard pressed as cash flow came to a halt. Allegations were made as to reasons for the closure and the methods and frequency of testing for coliform bacteria. Seafood workers actively engaged in the political process and a number of problems of the industry surfaced. The action resulted in the Governor activating and directing an interagency task force to protect, conserve and enhance Apalachicola Bay and the local seafood industry and local economy.

In summary, there is really nothing wrong with the oyster population in Apalachicola Bay. The population is very fecund, with few pests and little disease. Overfishing is presently the major problem as the resource has been nearly picked clean. The biological solution is to cultivate more oysters. This is a highly scientific procedure which requires expertise to do the job correctly and carry it out at every level of management. This must be accomplished in conjunction with increased education and mandatory cooperation at all levels and between all users in managing, exploiting and protecting the resource.

B. Biology

As water temperatures rise to about 26°C, oysters begin to spawn. Fertilization is external. Eggs and sperm in the water stimulate the release of more and more sperm and eggs until mass spawning occurs. An oyster may spawn several times during the spawning season which may last from April to November. Eggs soon hatch into trochophore larvae which develop into pelagic veliger larvae which swim for 2-3 weeks before settling on suitable substrate and are termed spat.

Apalachicola Bay is well suited to the growth of oysters. The American oyster, Crassestrea virginica is the dominant species, however a smaller species, Ostrea equesris does occur in the bay. Although salinities may vary rapidly, negatively affecting the glycogen content at different times of the year, oyster growth and reproduction remain excellent. Salinities vary widely within the bay and may range from 0-42 ppt at Porters Bar to 16-43 ppt at Indian Pass over a year (Ingle, 1951). However, the rapid growth is due primarily to the warm temperatures and the Apalachicola River which brings into the estuary enormous quantities of nutrient-laden fresh water known to increase the size or volume of oyster meats. Local harvesters have always known that when the winds are blowing from the east, the best oystering will be west of the river and vice versa. This is because the wind blows the fresh water over oyster bars and the oysters through osmosis increase their water content. Phytoplankton, bacteria and detritus produced in the bay are an additional source of food for oysters. A 3 inch oyster can easily be produced in a year's time and oysters have been known to reach the legal size from spat in as little as 39 weeks (Ingle, 1952).

Organisms which compete with oysters for substrate space include barnacles, Balanus improvisus, limpets, Crepidula fornicata, mussels, Mytilus spp., and bryozoans, Schizoporella spp. Barnacles and mussels can cover oysters, suppressing growth, while limpets were found to grow as fast as oysters during the first few weeks of post larval life. Both organisms compete with oysters for setting space ultimately reducing the number of oysters per unit of space. Predators include the oyster drill, Thais haemastoma; the crown conch, Melogena corona; whelks, Busycon spp.; flatworm (leeches), Stylochus frontalis; stone crabs, Mennippe mercenaris; blue crabs, Callinectes sapidus; and black drum Pogonias cromis. The fungal parasite, Perkinsis marinus (Dermocystidium marinum), does not extensively occur in the bay. Blue crabs are always a pest and do their greatest damage on small oysters. While black drum are a severe pest in Louisiana, there has been no evidence to indicate black drum to be a pest in Apalachicola Bay. Almost all oyster predators, especially drills, have a preference for higher salinities and so depredation by these predators only occurs during periods of high salinities. Salinity regimes in Apalachicola Bay are more favorable to the oyster than their predators.

C. Government Effort and Service

Government has provided a great deal of support for the oyster industry and Franklin County. The DNR is the most active agency maintaining a shellfish sanitation lab in Apalachicola, providing programs in oyster relaying and reef building, performing research on oysters, managing state owned lands and parks, administering the Apalachicola National Estuarine Sanctuary, and providing enforcement through the Marine Patrol. The DER attempts to minimize pollution threats to the bay through the permitting process while HRS monitors the oyster industry from a public health viewpoint. Florida Sea Grant has provided funds for research in the bay and provides some technical service through a marine advisory extension agent. University assistance has primarily come from FSU due to its close proximity to Apalachicola Bay and expertise in marine biology and oceanography. In the federal government the FDA is concerned with shellfish sanitation, and the Department of Commerce collects fisheries statistics through NMFS and funds Sea Grant through NOAA.

D. Artificial Reef Construction

Since 1949, over 800 acres of artificial oyster reefs have been constructed in Apalachicola Bay. Their locations are shown in Figure 3. The program seems only to be limited by a lack of funds and a controversy as to the correct method of constructing reefs. The DNR estimates an average of 5500 bu/acre of shell are used to build a solid reef a minimum of six inches off bottom. The DNR construction costs average $3700/acre of reef with an initial cost benefit ratio of $2.38 for every $1.00 expended. This benefit continues to grow over the years as oysters continue to be produced without any additional expenditures. The DNR allows harvesting to begin anywhere from 14 to 24 months after planting. Production is estimated at 400 bu/ac/yr but some reefs have been recorded as producing 700/bu/ac/yr with 1200 bu/ac/yr seeming to be a maximum under good management techniques. While the program receives widespread community support, it also receives much criticism as to the methodology employed in reef construction. The criticism ranges from they (DNR) don't know what they're doing, to just going out there and dumping the shells in a pile, to constructing reefs which never produce.

1. Methods of Construction

The Ingle method was the first method employed and its effectiveness is witnessed by the fact that those early reefs are still producing oysters today. The method is highly technical and must be carried out by a trained and experienced crew. The

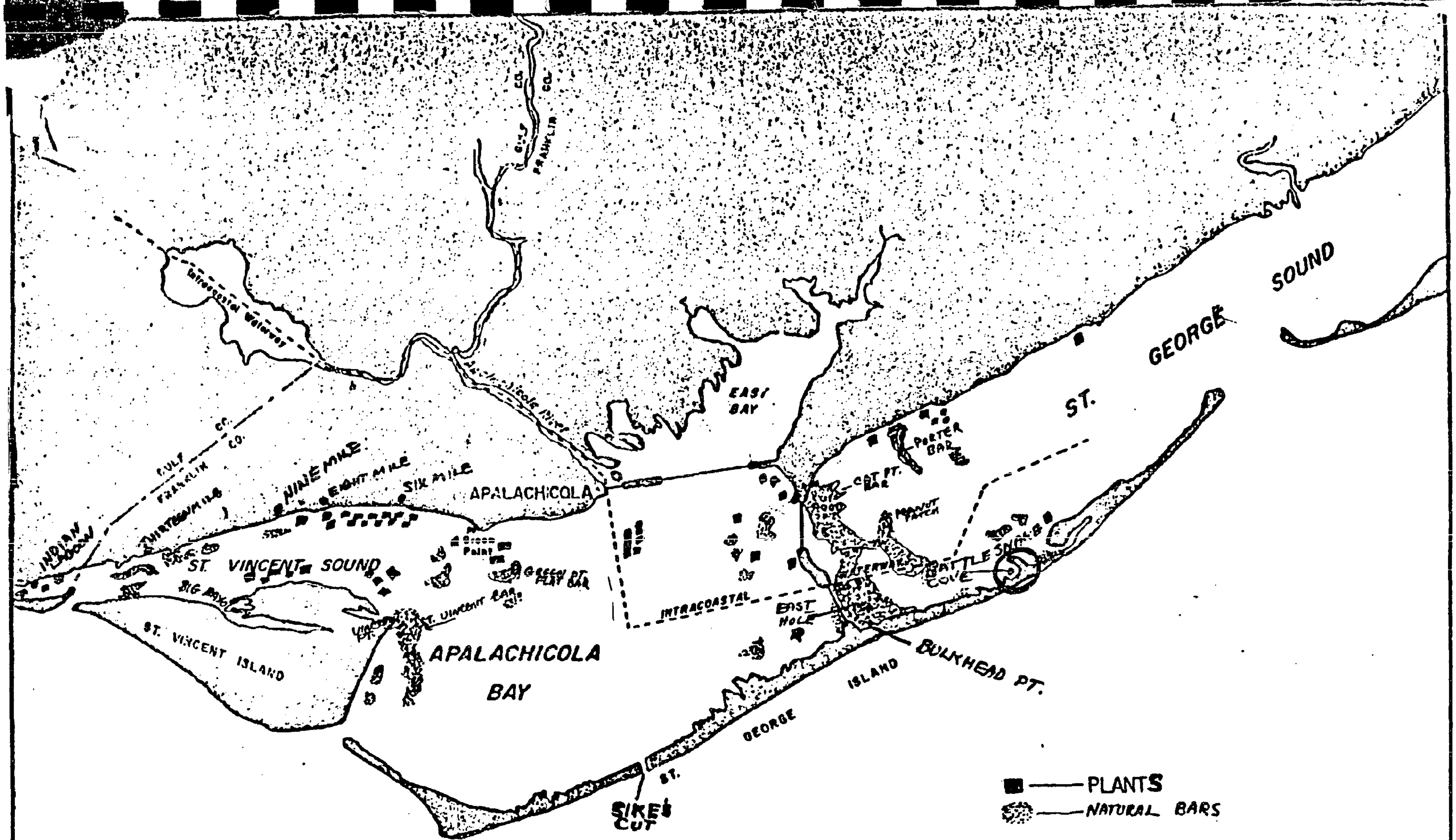

Figure 3
ARTIFICIAL OYSTER REEFS IN APALACHICOLA BAY

Source: DNR

substrate must first be checked and must be fairly firm with little or no soft mud. A mixture of sand and mud is best. The idea is to raise the level of shell 1-1.5 ft. off the bottom forming a permanent structure. The shell is brought out to the site on a barge. How the shell is laid is of great importance. The barge is set in place by sinking two spuds into the substrate to anchor the barge on each side and prevent movement. Shell is then blown off one side of the barge. The results are continuously checked by probing with an aluminum pole to insure a solid foundation is being built. When a firm sufficiently thick layer of shells is verified by probing, unloading of cultch ceases, the spuds are raised and the barge moved to a new barren area of bottom and the process is repeated. The new area should be as close as possible to the original plantings. Time of the year is also important. Reefs should only be constructed during the spring and summer months so that newly created reefs are settled by oyster spat and not by other organisms or plants. Alternatively, a lower foundation using green or unaged clutch may be layed down at any time of the year. A final layer of clean, bleached cultch would then be constructed on top of the lower foundation during the spring and summer months. This would help insure maximum set and reduce competition for space by undesirable organisms (i.e. barnacles, limpets and mussels).

Other methods have been employed over the years utilizing one spud or no spuds and with varying degrees of success. One possibility is to tie the front of the barge to an anchor 75 to

100 ft away from the barge. Buoys are then placed 50 to 60 ft from each side of the barge. The barge is then allowed to pivot in a pendulum fashion between the two buoys. As the barge swings towards one bouy, cultch is sprayed off the opposite side in a steady stream moving the barge towards the bouy. The process is then reversed. Frequent probing must still take place. Once the reef is completed, the barge is moved to an adjacent spot.

Reef building is a painstaking, time consuming operation. Correctly blowing off all the shell on a fully loaded barge is difficult to complete in one days time and the barge must be anchored overnight. Presently, a fully loaded DNR barge is brought on site in the morning and fully emptied within 4 hours by blowing shell from both sides. The barge then returns to the dock and is reloaded with shell for the next day. The operation has been designed to fit into a normal 8-5 workday so as to avoid overtime and stay within budget. A similar method was successfully employed years ago on a private oyster lease. DNR has done very little monitoring and evaluation of its reef construction activities.

Determining the proper method of reef construction should be a high priority. Oyster cultivation in Louisiana is a put and take method where the reef construction is more like planting a field of corn where the cultivator comes back and harvests by digging up the entire reef. The Florida method developed by Ingle is permanent. Once built the reef keeps producing year after year for a one time investment. Research should be designed to determine which method is the most productive over time and most cost efficient. Increasing reef construction efforts should increase oyster production in the bay. The feasibility of subcontracting reef construction to the private sector should also be examined as well as methods to pay for construction by the industry. A first step would be to identify and rank the best areas in the bay for planting. Substrate, hydrography, salinity and proximity to producing reefs are factors for consideration. Rehabilitation of old, unproductive bars to increase their productivity should also be examined for cost effectiveness. The improvement of old grounds should only be attempted when it is certain that conditions are favorable for the set and growth of oysters as some combination of conditions may have led to the demise of the bar. Conditions to be avoided include exposure to silt, shifting sand, potential storm damage, excessive or prolonged exposure to fresh water or high salinity conditions, rapidly vacillating salinities of wide range, and prevalence of parasites.

Three possible permanent reef configurations have been identified and should be evaluated as to their ease of construction, cost, and productivity. The configurations have been termed the pile or dome shaped reef, the row reef, and the flat reef, and are depicted in Figure 4. All may be constructed by the Ingle method or a method specifically suited to their configuration.

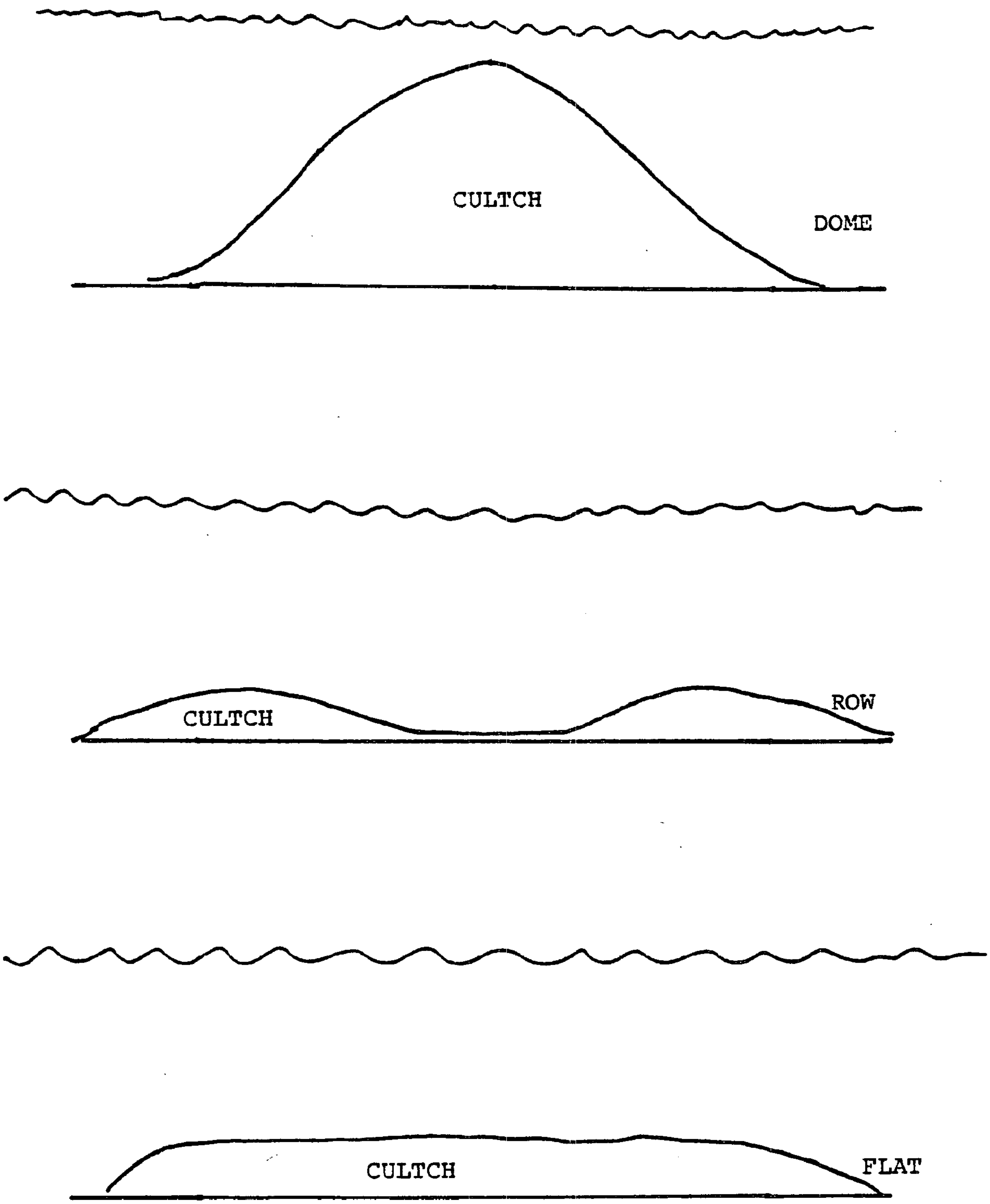

FIGURE 4
Reef Configurations

The dome configuration is formed by blowing shell off the barge into one large pile which slowly spreads out and settles. Many such piles already exist in the bay. The top of the domes are readily visible, lying a foot or so below the water surface. The upper portion of these domes are completely barren of any kind of attached or commensal life and cultch remains clean. The reasons for this are unknown, but may be caused by wave interaction preventing setting or organisms. Live oysters and associated organisms are found along the outskirts of the dome 15 to 20 ft away from the dome top and in 3 or more feet of water. A well designed monitoring program should determine the reason for the barren top. Those involved should investigate the optimum height of the dome below the surface minimizing wasted cultch, and find out where on the dome periphery lies the greatest concentration of oysters, the best growth, the optimum density for fastest growth, and the area of highest set, and then correlate these results with environmental factors to find out why.

The row configuration is best constructed by the Ingle method. The barge is locked into position, cultch piled and layed in a line, and the barge then repositioned to the front of the line, locked into place and the process repeated. The result is a long thin row of cultch one to two feet off the bottom with the greatest altitude occuring in the center of the row. A second row is laid parallel to the first row but spaced apart from the first row by the approximate width of a row. The spacing allows the oyster reef to grow and fill in the gap over time. The end result is a series of parallel rows equally spaced apart. A monitoring program would determine the optimum profile the cultch makes with the bottom substrate to produce a maximum crop of oysters.

The flat configuration is probably the most difficult to construct, and may be the most costly as well, but can theoretically produce the greatest yield of oysters. The flat reef basically covers the entire bottom with a uniform thickness of cultch. Optimum cultch height is unknown, but a good producing flat reef may be possible at a minimum thickness of 6 to 8 inches of shell. Experience reported by a private lease holder and on a tiny experimental DNR flat reef constructed in the 1950's, indicates this configuration is well suited to the production of single, well cupped select oysters if managed properly. A flat reef may be constructed by the Ingle method or by a method similar to the present DNR method where the barge is slowly pushed back and forth over pieces of the designated area gradually carpeting the bottom with cultch. The process must lay out plenty of cultch to insure the shell is not silted over. This method will only give satisfactory results on a hard bottom of mud and sand.

2. <u>Relay Program</u>

Oyster reef enhancement through relaying coon or stunted oysters from unproductive reefs to productive reefs is another popular program of DNR. However, relaying methodology also receives criticism from those who claim the coons are not relayed to the best areas or in too deep of water. Again, industry funding methods and participation by the private sector should be explored. The DNR relaying program should be accelerated as the dividends it pays are high. The DNR estimates that 100,000 bushels of relayed oysters can have a final retail value from $1.8-2.8 million per year. Relaying tends to break coon burrs up into single oysters which allows the oyster to grow more rapidly and with a more commercially desirable shape. Finally, when these transplanted coon oysters are ready to harvest, they are much easier to cull which allows the harvester to spend less time, catching more oysters.

E. Marine Patrol

The Marine Patrol has one of the most important yet one of the most difficult jobs in Apalachicola Bay. The Marine patrol is charged with enforcing the laws and protecting the resource. However, manpower shortages, difficulties in catching violators, and low fines and conviction rates by the courts are discouraging to the individual officer. The number of oyster boats compared to the number of officers makes the job difficult and unselective. The major focus of law enforcement should be on preventing the taking of unculled or small oysters.

Harvesting of undersized oysters (less than 3 inches) is severely damaging the resource. The law currently allows only 15% of those oysters harvested per bushel to be undersized. Time spent culling is an extra cost imposed on the tonger, but the added culling effort aids in preserving the resource, adds to the price received per bushel, and makes the job of shucking much easier.

If DNR severely enforces the law, then many oystermen will not go out oystering. Oyster dealers demand that enforcement be carried out on the bay and not in their houses once the oysters are purchased. The DNR maintains the job would be easier if they could check the oyster houses. The dealers maintain they do not have the manpower to check each bag of oysters they buy. The fact remains that some houses or some persons are buying the small oysters thereby encouraging their harvest. The problem is further complicated by the fact that court fines are small and the catch is never confiscated thereby making it profitable to harvest undersized oysters even if one gets caught and fined. This is especially true of oystermen caught illegally poaching oysters from a lease site. The oysters are usually sold before the violator is apprehended and charged only with trespassing. The fine is much less than the value of the oysters, which is forever lost to the leaseholder.

Culling and harvesting only legally sized oysters is a sound management practice which will help preserve the resource. If the law were enforced, the result would be enhancement of the resource. The solution should be a compromise among workers in the industry (Seafood Workers Association), oyster dealers, and the Marine Patrol. Oystermen feel the Marine Patrol should have more leeway in enforcing the laws rather than unilaterally enforcing the laws. That is, persons who are not culling should be vigorously policed, while those who cull their catch should not be rigorously held to the 15% undersize maximum. Non culling is locally referred to as tonging in the hole, when an oysterman tongs oysters directly from the water into the hold of the boat. The oysterman rapidly fills up the hold with unculled oysters and has many more bushels to sell. Dealers need to cooperate more by putting pressure on those dealers who buy undersized oysters or those tonged in the hole and by only buying from oystermen with good reputations for culling. Finally, oystermen should take pride in culling their catch by sacrificing a little today for more tomorrow.

Conversations with oystermen and dealers revealed the need to do something about enforcement problems. Some suggested solutions to helping preserve the resource are presented as follows:

1. Limit the amount of recreational tonging in the bay.
2. Limit the amount of permits issued for oystering. Then permits could not be sold nor passed on. Franklin County residents should have first priority.
3. Limit the amount of bushels of oysters which can be harvested over the year by a single permit. Record keeping could be done by the dealers, marine patrol or by punching or stamping the permit. Posting a bond may help insure the limit is not exceeded.
4. Close off depleted bars until such time as they begin producing again. Rotate closing off different areas of the bay to allow growth.

5. Reinstate a closed season during summer months.
6. Increase the amount of the fine substantially each time a violation is repeated until a permit is finally revoked for a one year period. Make penalties a real deterrent.
7. The Marine Patrol could go out on the bay in mid-morning and stop all boats riding low in the water. Most likely these will be ones tonging in the hole (no culling). Vigorously enforce tonging in the hole.
8. Require tongers to go by a Marine patrol check point to be inspected, have bags counted and an inspection slip issued. Dealers could then only buy oysters from a person with an inspection slip.
9. Dealers, Seafood Workers Association members, and Marine Patrol meet and make a public list of those known to be tonging in the hole and those known to be buying undersized oysters.
10. Require tongers to post a $2500 bond which would be forfeited upon the third repeat violation.
11. Marine Patrol should rigorously enforce illegal trucks purchasing oysters. All oysters tonged in the bay should have to go through a certified house.
12. Change the law for persons caught poaching on a lease from trespassing to theft. Impose stiffer fines for those persons caught taking oysters from public grounds

and passing over leases to either cull or claim the oysters came from the lease.

F. Development Potential

DNR estimates put total oyster production acreage, both natural and artificial, in Apalachicola Bay at roughly 6000 acres. Conservative estimates indicate an additional 40,000 acres of bay bottom are suitable for oysters (Andree, 1982). Clearly the potential to expand production exists just by increasing acreage through reef construction. Odum et al, (1974) using the net primary production of a marsh-estuary system (18,000 lbs/ac/yr) and a 10% conversion efficiency to oyster meat calculated that 4 acres of estuary would be required to support one acre of instensive raft culture of oysters (17,500 lbs oyster meat/ac/yr or 2400 bushels). Assuming Apalachicola Bay is similar to the estuary described by Odum and knowing that additionally up to 214,000 metric tons of organic matter are transported into the estuary each year by the river (Livingston, 1983) the 40-50,000 acres of potential production in Apalachicola Bay could possibly yield more than 500,000,000 lbs. (approximately 68,500,000 bushels) of oyster meat each year. A more conservative estimate would be to multiply the 50,000 potential oyster acres times 4500 lbs. meat/ac (225,000,000 lbs./yr total) which is the average production of intensive, well managed systems in Long Island Sound. Even using the DNR estimated average production of 400/bu/ac/yr would yield nearly 150,000,000 lbs of meat per year.

In any event, any of the three figures are considerably greater than the 4,942,000 lbs harvested out of the bay in 1983. The potential for oyster production in Apalachicola Bay seems primarily limited by the aspirations of the members of the industry and natural mortalities.

Nationwide oyster production is constrained by pollution and loss of grow out areas due to water use conflicts. This is not yet the case in Apalachicola Bay. Designation of the bay as a sanctuary was an important step in recognizing the importance of the estuary and should help to protect and enhance oyster habitat as well as other species habitat. However, protecting the estuary and the water quality necessary for oyster production from pollution and other man made alterations is not a simple task.

Water quality in the bay is highly dependent on the water quality of the river. Maintaining water quality in the river and eliminating upstream sources of pollution is necessary to insure survival of the oyster industry. Commerical development around the bay, especially on St. George Island, can have significant deleterious effects on both habitat and water quality. Since oyster culture requires space in the estuary which is in conflict with other uses, coastal zone planning at the local, state and federal levels should recognize the importance of allocating space in the bay for food production and should devise methodology for protecting this space. Some of the competing use problems can be minimized by recognizing the compatibility of some areas for more than one use. Recreation is one such competing use. Recreation, especially sports fishing, is placing a good deal of pressure on the commercial fishing industry throughout the state as recreation dollars become more important than fishing dollars. Educational programs aimed at different users and advocating the unique dependency of oysters on an undisturbed natural environment are the long term solution for resolving multiple use conflicts.

Annual oyster consumption in the U.S. is expected to exceed 125 million pounds by the year 2000 (NADP, 1983). This increase is not anticipated to be met by expansion of the public fishery of natural oyster populations. A lack of suitable space is another constraint. The opportunity to meet the demand through private oyster culture utilizing innovative techniques is significant. Apalachicola Bay has suitable and abundant acreage to expand the public fishery and develop the private fishery. The mere fact that undersized oysters are routinely harvested and sold is indicative of the market demand. In order for the Apalachicola oyster industry to cash in on this projected demand the industry must: increase production by increasing acreage and employing culture techniques; increase harvesting efficiency; upgrade processing and develop new products; enhance the value of current production by developing a quality oyster for the luxury market; and protect the natural integrity of the estuary.

G. Basic Oyster Culture Systems

The increasing demand for oysters coupled with declining production from natural stocks, enhances the feasibility of culturing oysters for market. Numerous oyster culture techniques exist and may vary as to their degree of control by the culturist. The techniques may range from simple reef construction on public or leased grounds to upland facilities where every stage of the oysters growth is controlled. Culture of oysters can increase the overall quality of the product, produce a regularly shaped oyster sometimes with reduced numbers of fouling organisms and high in glycogen content for the gourmet trade, and supply a year around market demand.

1. <u>Hatchery Technology and Spat Collection</u>

The oyster population in Apalachicola Bay is healthy and very fecund. Oysters have never failed to spawn in the bay and this prolific natural recruitment seemingly makes the need for a hatchery uneconomical. However, there have been some failures of natural setting on the Gulf Coast in recent years which may require the re-evaluation of hatchery seed in the years ahead. In fact, certain bars or areas of the bay may not consistently have spatfall each year. Of course, too much spatfall can result in crowding and stunting of oysters. Certain types of off bottom oyster mariculture, including those destined for the luxury half shell trade, require spat produced in a hatchery or collected in natural waters on artificial cultch. Finally, hatcheries can produce a genetically superior strain of oyster and enlarge the base of genetic knowledge essential for the long range success of commercial breeding. If oyster production in Apalachicola Bay expands to its full potential, new products are developed, and new high priced markets are sought, then, inclusion of a hatchery in a mariculture plan, as an emergency backup source of seed, becomes a viable possibility for the future.

Oyster hatchery technology is well established and was first accomplished in 1920 by W. F. Wells and refined in the 1940's at Milford Harbor, Connecticut by Victor Loosanoff and H. C. Davis. Further modifications have been made since that time, but the methodology remains essentially the same. Reproduction is controlled by environmental manipulation and spawning can be induced year round. Broodstock are usually maintained at 10-12°C until they are required for spawning. The broodstock are then conditioned by slowly raising the temperature to 18-20°C for a period of two to four weeks. The temperature is then raised to 26°C to trigger spawning. Newly hatched larvae are transferred to rearing tanks where they are fed either cultured or naturally occurring phytoplankton. Cultch material is then provided and the spatfall settle within 15-20 days. Cultchless spat are now produced by providing plastic screens or metal sheets to catch the spat. Cultchless spat can then be individually moved for growout in trays or racks producing that regularly shaped luxury market oyster. Many hatcheries now take orders, spawn the oysters and ship the larvae to the customer who then settle the larvae out on their own cultch usually in tanks or plastic swimming pools. This saves extra work, space and money in the hatchery for grow out and setting the larvae as well as reducing shipping costs to the customer. One hatchery can then produce several billion larvae in any given year.

Construction of a large year round shellfish hatchery can be costly and failure in any one year may be disastrous for investors. Cost is dependent on the volume of product and competition with other sources of seed, especially those produced naturally. Matthassen (1983) has described a hatchery which has operated for many years on Long Island and is limited in terms of production, but is inexpensive. The hatchery is only used during the warm summer months and has a total capital investment of $1000. One person is required to maintain the algal food supplies and rear the larvae through settling over a two month period. Two additional persons are required to maintain and operate the juvenile grow out system. Not much can go wrong with this simple system as it is operated at the time of year when natural conditions are most favorable to spawning. The system is capable of producing up to 6 million seed during the two month period.

Seed production may also be accomplished in natural waters by collecting spat on artificial cultch. Strings of shells, sticks, nylon bags and other materials have been used to collect spat. The key to the process is knowing the best time to set out the cultch and collect the settling larvae rather than some other organisms. The best time in Apalachicola Bay seems to be a function of temperature, salinity and location. A minimum salinity of 20 ppt and temperature of 26°C are required for mass spawning, and most recorded mass spawns were at 28°C (Ingle, 1951). While mass spawns may occur the second week in May at Porters Bar, the best time seems to be in late June, July and August for most of the central and eastern portions of the bay. The best time to collect spat in St. Vincent Sound (13 Mile) and Indian Pass is in August. Checking cultch set out to collect spat at frequent (2 weeks) intervals is important. Cultch must be clean or bleached to insure the highest rate of catch. Freshly layed cultch will lose almost all of its usefulness for oyster attachment after about four weeks due to competition from other organisms, especially barnacles. High spatfall is associated with higher salinities, while best growth occurs in less saline waters with higher concentrations of nutrients and detritus. Production at Porters Bar has declined in recent years, but spatfall remains high. In Louisiana, the state maintains oyster seed or spatfall grounds in higher salinity waters west of the Mississippi River. Private lease holders then dredge up the seed oysters and relocate the seed to more suitable, less saline growout areas.

As oyster production increases and the industry expands, hatchery plans should be developed to insure continued production and circumvent natural disasters. The mechanics of setting up a hatchery, especially securing a competent hatchery manager, will require considerable time and should be well planned. Collection of spatfall on cultch in natural waters is a suitable method for obtaining seed for various off bottom culture techniques. A seed collection area, such as in Louisiana, could be maintained in the eastern end of St. George Sound. Establishing a low cost hatchery as part of a multi-use facility, as described in the Cooperative Oyster Lease section of this report, is recommended to insure the long term success of the industry. Hatchery procedures should be undertaken with caution as technical and biological problems may be encountered using the traditional Milford or Wells-Glancy procedures. These site specific problems may be overcome through innovation and by drawing upon oyster culture experience in Apalachicola Bay.

2. Bottom Culture

Bottom culture is the only culture technique presently used on leases in Apalachicola Bay. It differs from public bars in that a higher degree of management is required resulting in an increase in production. Growth and survival of cultured oysters is related to the quality of the beds or bars which should be located on sand and mud substrate in 3 to 10 feet of water. Tidal currents should be sufficient to flush the bed and maintain good water quality. Seed oysters may be scattered on the bed or spat allowed to recruit naturally. Once the oysters are established, management is limited to predator control, removal of silt, and thinning or culling and moving oysters to other beds. Yields can reach 4500 lbs of meat per acre per year. The remainder of this section will describe a successful bottom culture operation formerly carried on in Apalachicola Bay.

Shell should be planted to a minimum of 12 inches to obtain a hard bottom which will not easily silt over. The shell should be spread as flat as possible to cover a maximum amount of bottom area. A margin of uncovered bottom should be left around the lease perimeter to reduce poaching and clearly delineate where oysters were harvested. If natural setting is used to sow the lease, then a waiting period of 20-30 months from the time the shell is planted will be required to produce select oysters. The time in each case will be dependent upon the quality of the habitat as oysters exhibit variable growth rates. The waiting period is a management tool necessary to produce a steady supply of superior oysters with a higher market value. Harvesting at 14-18 months after planting, as is often the case with artificial reefs created by the state, produces a less than top value oyster. These oysters are sometimes fragile and are often killed during harvesting or damaged and culled back into the water where they eventually die.

Management should only allow selects to be caught and carefully culled to obtain maximum production. Workers must be controlled. A harvester should make more money working the lease as he can catch two or more times as many oysters on the lease in the same amount of time as he would working public bottom. This increased efficiency is supported by early accounts of Franklin County, where in 1890 three men working 12 hours each could harvest 100 bushels of oysters. The lease should be worked a variable amount of days, usually 3-4 days per week. Careful culling serves to maintain the lease and insure production the following year. The lease produces best when the winds carry fresh water from the river over the lease. This is due to the oysters absorbing more water into their tissues when salinities are lower. The excess water does not decrease quality as it is readily lost when salinities increase or the oysters are shucked. For the best monetary yield, the lease should be worked from early November through the end of March, because the condition of the oysters (percent glycogen in their flesh) is best during that time period. The oysters are more desirable, less watery, and have a higher yield. Annual production in this example, ranged from 1100-1300 bushels per acre.

The lease was not worked during the summer due to the leaseholders opposition to summertime oystering. Oysters are of inferior quality during the warm months partly due to diversion of energy, normally used for growth and glycogen production, to spawning. In addition, the warmer water temperatures require more energy to be expended in the pumping process to extract approximately the same amount of available food in the water. However, if sufficient food is available, the expenditure of energy can be compensated for, in which case high quality can be sustained.

Weak oysters when tonged and placed on a culling board are often injured and culled back into the water. If salinities are higher during the summer, predators are usually more abundant and the injured oysters become easy prey. The net result is an increased mortality, a decrease in next year's crop, and a poorer quality product. By harvesting during the prescribed months when oyster quality is best, yields and prices are highest. Maintaining the quality and price should be more important than oystering in the summer. To remain competitive, oysters harvested in the spring can be frozen in flexible pouches and sold during June, July, and August. Careful attention must be given to processing methodology, particularly temperature constraints. Fresh oysters can be obtained in September and October from tongers working public beds.

Work on a lease does not cease during summer. Clean, bleached shell should be sprinkled over the lease area during mass spawning periods to insure maximum collection of spat. The cultch should be replenished every year as silt, mud and algal growth reduce the effectiveness of the existing cultch to keep catching spat. A permit may also be obtained to collect and relay coon oysters to the lease site. Salinities should be the same at both the lease site and coon site or the coons will have to be acclimated prior to placing on the lease. A coon burr can be turned upside down and gently tapped while extended over the water to allow the small oysters to fall off or just thrown over the side and it will break up naturally after settling on the bottom. By the following February or March under good growing conditions these coons could grow into selects. Finally, the summer months afford an opportunity to clean, repair and renovate oyster harvesting gear. So, leases offer the added virtue of year-round employment for oystermen.

3. Off Bottom Culture

Off bottom culture of oysters is not practiced in Apalachicola Bay. Off bottom culture offers the advantages of utilizing the entire water column, maintaining a higher degree of control over culture conditions, and producing an individual high quality product. The site must be protected from severe waves and wind, must have sufficient and frequent water exchange, must contain adequate nutrients to produce an abundant food supply, and be free of any industrial wastes or sewage. Off bottom culture requires leasing the water column which creates more legal problems especially with competing users. The site must be away from navigable channels, not be unsightly, and not interfere with commercial or recreational fishing. The four most common off bottom methods are rack culture, raft culture, long line culture and tray culture.

a. Rack Culture

The rack method is for shallow water where cultches with attached seed are hung from a rack fixed on the bay bottom 4 to 12 feet deep. The rack is constructed of marine treated poles driven into the sediment. These vertical poles are connected by horizontal poles at any desired spacing and crossbraced. A typical rack is usually 8' x 20', anchored with 8 poles, and having 5 horizonal (20') poles from which oysters are hung. Wires or strings are strung with cultch six inches apart containing spat. The wires are hung at equal intervals from the poles, but remain six to twelve inches off the bottom which eliminates predation by conchs and oyster drills. This method has primarily been used in Japan to collect seed or harden oysters prior to final growout. The method may be suitable in shallow, protected areas in St. Vincent Sound and along St. Vincent Island. Tides would have to be monitored to insure there would be no prolonged exposures.

b. Raft Culture

Raft culture is the most commonly employed off bottom technique used in Japan and much of the Far East. Rafts can be made with bamboo, cedar, or even PVC. Rectangular rafts are framed with poles or boards spaced two feet apart and cross braced. Rafts are usually standard in size and construction to facilitate ease in production. The rafts may reach 16m x 8m (55 ft x 28 ft) in size and are often laid out in lines ten feet apart, tied together and anchored. A raft may also be viewed as a movable oyster bed and relocated to safeguard oysters from storms, sudden pollution events, or other disasters. The rafts are buoyed by styrofoam or high density urethane foam encased in polyethylene bags to protect them from fouling. More floats must be added as the oysters grow and the weight of the raft increases. The standard raft may suspend 500-600 strings of oysters. Seed oysters are attached to cultch and strung 6-8 inches apart on the string or wire and then vertically suspended from the raft for growout. Production varies with the size of the raft and length of the strings. Rafts usually last a minimum of five years.

Experimental raft culture was attempted in Delaware Bay in 1975. The rafts withstood environmental conditions in small tidal rivers, but were severely damaged by waves in the open bay. Researchers concluded that physical factors would prevent large scale raft culture along east coast estuaries. Sheltered waters are a must in order to protect the raft structure. Sheltered sites appear to be limited in Apalachicola Bay. Breakwaters which reduce wave intensity but allow flow may be a possible solution. An economic analysis was performed using 1974 dollars, a raft cost of $2610 per unit producing 600 bushels of oysters with a 40% mortality harvested every other year, and a selling price of $22 per bushel. The analysis showed after 14 years an overall loss would be suffered regardless of the price of oysters (Aprill and Maurer 1976). However, Delaware Bay does not possess the conditions suitable to rapid growth rates which are found in Apalachicola Bay. With the increased demand, improved methods, and new markets, the economics of raft culture in Apalachicola Bay deserve a closer look. Additional problems with raft culture include control of fouling, high labor costs, and theft.

c. <u>Long Line Culture</u>

Two parallel ropes, 1-2 inches in diameter and 100-250 ft long, are linked to floats, 10-25 feet apart, and stretched out over the water by anchoring on both ends. Strings of cultches are then hung from the long lines, but do not touch bottom. This method can be used in rough or deep seas as it resists wind and waves effectively.

While Apalachicola Bay has few deep areas where this method might be employed, a modification of the method may have considerable potential. Either the vertical strings of cultches can be shortened to one or two feet below the long line or one or more additional long lines with cultches could be strung horizontal and parallel to the surface long lines but at a depth of one foot or more. The method might be modified even further by combining it with rack culture. Poles would be driven down into the bottom substrate and lines with cultches tightly stretched horizontally between the two poles, one to two feet below the surface. The exact depth should be determined tidally and by growth factors, so that the cultch line could be set at a depth where it was occasionally exposed to air. This would eliminate most fouling organisms and predators. The combined long line/rack technique seems to satisfy both the shallow depth and the roughness found in the bay.

d. Tray Culture

Trays may come in several sizes and shapes and may be constructed with a variety of materials. A typical tray has a hardwood frame (1x3 inch wood), plastic or galvanized hardware cloth as a bottom in which to place oysters, and a wide mesh net cover to help keep predators out of the tray. Trays may be as small as 3 ft x 3 ft for easy handling or as large as 3 ft x 9 ft for large operations. Trays may be tarred before use to increase their life. Trays are used extensively in Australia, Great Britain, and the Netherlands, but very few growers use them in the U.S. Tray cultivation may be carried out on soft mud flats, on racks, or suspended from rafts. They can be set out as a single unit or stacked in multiple layers. Trays should be kept off the bottom and at optimum growing depth which must often be found through the grower's experimentation. Trays must be protected from wave action which is most often accomplished with a breakwater. Trays require regular attention and inspection to insure that oysters have not clumped up or washed off the trays. Periodic culling and separating results in faster growth and a better shaped oyster. A bushel of oysters can be produced in a 9 x 3 tray and about 400 of these trays can be accommodated in one acre of water. This is approximately the same production which is presently being achieved on artificial reefs in Apalachicola Bay. With the good growing conditions of the bay, it may be possible to increase the number of trays per acre and thus, production.

A major barrier to profitable tray culture is effective fouling control. Fouling can reduce growth by competing for food and space, covering oysters with silt, and reducing water circulation by plugging the tray screen. Apalachicola Bay is one such place where prolific fouling could prove to be a major constraint. A recent innovation has been to use biological controls. Researchers in Maine found that placing a small (62mm) rock crab, Cancer irroratus, in the tray eliminates nearly all fouling and silting. The foraging by the crab moves the oysters about such that there was no silt build up around the oysters. The crab selectively fed on mussels in the 20-30 mm size range. Crabs too large (>100mm) will also feed on the oysters. Biological fouling control holds great promise for oyster culture as it improves growth and reduces labor costs.

H. Intensive Systems

Intensive systems for rearing oysters from spat to larvae have been experimentally tested and commercially developed. A recent high technology recirculating system developed at the University of Delaware was found to be, at present, economically unfeasible primarily due to the costs associated with algal culture. A large commercial scale flow through system in Hawaii went out of business in 1983 after five years of operation. Thus, while technologically feasible, the economics are presently unfavorable.

An oyster fattening project was undertaken during 1978-81 in Apalachicola. The project placed oysters in shallow trays through which seawater enriched with cornmeal flowed through. Substantial fattening and improved quality were obtained within two weeks of artificial feeding, but the economics were not favorable. The extra cost per gallon at that time could not be offset by increased quality. This technique should not be abandoned. As the industry grows, high priced markets for quality product will be developed. Selects, with high glycogen content, harvested uring winter cannot naturally be produced in the bay during summer. In order to service these lucrative markets year round, oysters harvested during the summer could be passed through the fattening plant prior to market. The extra cost could be passed on or recouped by maintaining the market year round. The fattening plant could be part of the multi-use facility described in the Cooperative Oyster Lease section.

I. Oyster Harvesting

Hand tonging of oysters is the only method of harvesting oysters ever employed in Apalachicola Bay. The method requires skill and strength and is considered to be a local craft. However, hand tonging is inefficient and adds to the overall low productivity and inefficiency of the entire oyster industry. The net result is a competitive disadvantage for the Apalachicola industry with mechanized oyster industries located elsewhere (Rockwood 1973). Productivity of hand tonging is just not competitive with mechanized harvesting. The people of Apalachicola need to realize the necessity of upgrading their primary industry to compete with oyster producers elsewhere resulting in higher local earnings to harvesters, shuckers and dealers which will help insure the survival of the industry in the future.

Mechanized harvesting with an oyster dredge does not have local approval and in fact, is presently illegal in Franklin, Wakulla and Gulf counties. Reasons often cited include loss of jobs and damage to the ecology of the bay. The idea of an oyster dredge is a popular misnomer. An oyster dredge is not really a dredge, but a scrape and it has no relationship to a dredge which digs a channel. Oyster dredging or scraping can be an efficient method of harvesting when carried out properly on a lease, but should never be employed on a natural reef.

A number of small scrapes are presently employed in oyster harvesting. For a mechanized oyster harvester to be successful, it must reduce the manual labor required to harvest, be economical, and be environmentally acceptable. One such scrape can operate in 2.5 to 11 feet of water, harvest 500 bu/hr with a three man crew, and causes negliglble damage to the shell matrix and less than 5% damage to harvested oysters (Collier 1981). Dredging or scraping will harvest more shell and cultch material which must be culled and replaced on the oyster bed. Culling thus becomes a limiting factor of oyster dredging. Improvements in culling efficiency are not easy as the task must still be completed by hand or in this case, by a number of hands. With mechanical harvesting, culling may be made more efficient by only culling the larger and easiest oysters to pick from the pile of shell and oysters. The remainder would then be thrown back overboard to be harvested and culled another day. Since the dredge produces so much more product from which to cull from, this method would be a step towards improved efficiency.

Rockwood (1973) thoroughly reviewed alternate harvesting methods in Apalachicola Bay and recommended the use of mechanical tongs. Mechanical tongs are operated off a winch, close under their own weight, and do little ecological harm while doubling efficiency.

Harvest efficency must be achieved on leases due to the cost of developing the lease. Scraping may be desirable for leases if carefully employed. The leaseholder could be required to post a minimum of a $10,000 bond to insure scraping was carried out properly and only on the leased area. Scraping could also be efficiently utilized in the relaying of coon oysters to productive public bars or leased areas.

J. Marketing Needs

A complete review of the Apalachicola oyster industry's market structure should be undertaken. A clear distinction in accounting should be made between oysters harvested from Apalachicola Bay and those trucked in from Texas and Louisiana. These oysters are not as good as oysters grown in Apalachicola Bay. Assessment of bay oysters should be broken down by season, size, product type and price to determine the type of oyster most in demand during a particular month which brings the highest price. All values should be reported as gross income or gross market value. Average monthly output for each product type (shucked and singles), location of wholesale, retail and restaurant markets, identification of untapped or not fully developed regional and national markets, range of wholesale prices by season, comparison of wholesale prices received in Apalachicola with those received elsewhere, and location of competitors, should all be assessed for precise marketing information.

K. Oyster Research Needs

Although the oyster has been one of the most intensively studied marine organisms in the world and thousands of technical papers have been published on the oyster, there remain gaps in scientific and technical knowledge necessary to fully develop commercial oyster mariculture. Research needs include those important to general oyster mariculture and those specifically related to increased oyster productivity in Apalachicola Bay. Needs related to the details of artificial reef construction have previously been discussed and shown to be of great importance.

Determining the productivity of Apalachicola Bay and the standing crop of oysters it can reasonably sustain should be a long term research priority. This might be accomplished by determining the biotic potential of the oyster or its capacity to increase in abundance under optimum environmental conditions. The biotic potential must be balanced by enviromental resistance or the sum total of all environmental factors that prevent the biotic potential from being realized. What factors limit abundance and when, where, how and to what extent these factors are limiting need to be determined for the oyster throughout its lifecycle and in determining weak vs. strong years. Factors which should be examined to determine environmental resistance include spawning, larval development, setting, loss to benthic community, availability of attachment sites, survival, predation, overgrowth by competitors, suffocation, shell fracture, and other mortality. Most of these factors should be resolved by focusing the research on the best methods to build permanent reefs. The results will be useful in determining the maximum acreage suitable for oyster growth in the bay as well as the maximum number of oysters the bay system is capable of producing each year.

Although growth and behavior of oysters is well understood, a need exists to continue investigations of off bottom culture. Growth rates using various off bottom techniques should be measured at suitable sites in the bay. Many off bottom techniques are primitive and labor intensive. Research on facility design and engineering of low cost culture devices requiring a minimum amount of labor are needed and should accommodate navigation and recreation. Harvesting methods are primitive and are dictated by law. Mechanizing harvest gear including culling and sorting, based on local conditions should be a high research priority. Improved quality control is needed in the areas of regulation and inspection, rapid detection of bacterial and viral pathogens, and economical depuration of oysters.

Major gaps of knowledge in genetic research of oysters should receive more attention as oysters can be reared throughout their life cycle in captivity. Methods to select strains to improve hatchery production, developing strains resistant to disease, selecting for traits to improve growth, size and weight, and understanding the importance of wild gene pools are all necessary for the long range success of oyster mariculture. Understanding natural setting, designing new spat capture systems, and development of artificial cultch are all important in the production of seed. Growers need to know the nutritional requirements of oysters at every stage of growth especially the nutritional needs of oysters in natural habitats. Knowing the quantity and species of phytoplankton and other food utilized by oysters in the bay would contribute to selecting sites for growout.

More research is required in the control of diseases, parasites and predators. Microbial diseases can contribute to mass mortalities, especially oysters under stress. Development of disease resistant oyster strains should be closely tied with genetic studies. Several effective drugs and antibiotic for disease control are presently available, but more effort in this area would be beneficial. Almost everything harmful to oysters deals with high salinity waters and research relating salinities with predation and disease is needed. Eliminating commensals and competitors will improve the appearance, quality and value of oysters. Depredation by drills, conchs, crabs and fish are extremely damaging to oysters. Efforts to reduce or eliminate predators could save the industry considerable money and increase productivity at the same time.

Research needs for the Apalachicola oyster industry are ranked in the following order:

(1) Develop the best method for oyster reef construction resulting in the most productive reef over time;

(2) Develop mechanical means of shucking and mechanical devices to improve harvesting and culling efficiency;

(3) Control or elimination of conchs and drills;

(4) Determine the biotic potential of the oyster in the bay; and

(5) Determine growth rates of oysters cultured off bottom in trays, rafts, racks and strings.

L. Open vs. Closed Seasons

Management of oyster resources have traditionally been accomplished through open and closed seasons. Until 1977, oystering in Apalachicola Bay was prohibited during June, July and August. The reasoning behind a closed season deal with health concerns due to increased bacteria counts during warmer months; spawning and recruitment are accomplished during summer; and the oysters are debilitated, much weaker and as a result do not have the flavor normally found in the cooler months. The closed season basically allows the resource to recover from fishing pressure and reproduce. Additional management reasons were provided in the section on bottom culture. In 1977, the bay was opened to summer oystering in designated areas. The designated areas, described by statute, are normally closed during the remainder of the year and those oyster bars normally open during the year, are usually closed during summer. This rotation means that all oyster bars in the bay are closed at some time during the year. Designated summer and winter areas are presently under consideration for revision. The law is specific to Franklin County as all other oyster grounds in Florida are closed during the summer season. The year round open season then would seem to be based more on politics, than biology.

It is often alledged that mortality of larger oysters (over 3 inches) is as much as 50-70% in late summer. This is probably true if the animals are under stress, but if growing conditions are favorable, no such death rate need be anticipated. But, based on these erroneous allegations an argument has been made that summer oystering simply allowed animals to be harvested that were destined to die later. This argument has obvious weaknesses when and where environmental conditions are optimum. In fact, the oyster fattening project showed when temperatures are high, but food is not limited, oysters have enough energy to meet both the need for body maintenance (pumping) and growth, and will continue to grow and be healthy.

Summer oystering would seem to benefit the entire industry as supply is continuous and markets served regularly. Losing markets to out of state producers is a major concern to dealers. They believe that keeping the bay open, even if no oysters are harvested, maintains their competitiveness. However, it must be noted that the majority of oysters shucked and shipped out of

Apalachicola are trucked in from natural producing beds in Texas and leases in Louisiana. That is, production is continuous and markets are regularly served regardless of the amount of oysters harvested during the summer from the bay. Shuckers remain working and dealers continue to have product.

The oyster tonger or harvester is the segment of the industry most benefited by summertime oystering. A closed season would then cause economic hardship on those entirely dependent on oystering to earn a living. Many oystermen do little or no harvesting during summer months due to on shore employment, employment in other fisheries (shrimp, crab), or due to their principles on conservation of the resource.

Rockwood (1973) examined price data, yield statistics, and growth and survival characteristics of the Apalachicola oyster and concluded that a longer closed season (May through September) made a good deal of economic and biological sense. The biological sense was suggested in the '50's by Ingle and Dawson (1952; 1953) when they reported glycogen content to vary seasonally. If oysters normally harvested from May to October were allowed to grow until the following winter, then they would double in weight, have high glycogen content, and twice as much oyster meat would be produced with the same amount of work effort. Rockwood concluded the gain in value could approach 225%. Therefore, wages earned by oystermen are theoretically higher with a closed season than with an open summer season for the same amount of fishing effort. In addition, the larger oyster fetches a higher price.

Biological and economic research efforts should be able to provide some clear choices between an open and closed season. The integrity of the resource is most important, as there will be no jobs if the resource is depleted. If the resource is exploited properly and an oysterman can earn an annual living in nine months time, then the summer season should be closed. If the resource can significantly increase in productivity and oystermen cannot make a decent living in nine months, then an open summer season would appear reasonable. Assuming that productivity can be significantly increased in the bay and new markets developed for a high quality brand "Apalachicola oyster", then supplying that quality oyster year round would be a high priority. The best way this can be achieved would be to carefully harvest the lower quality oyster found during the warmer months and pass the animal through the oyster fattening facility and depurate if necessary. This is one mariculture practice recommended for Apalachicola Bay.

M. Leasing

1. The Case Against Leasing

Most residents of Franklin County are opposed to private leasing of bay bottom for the cultivation of shellfish. They fear that only the wealthy could engage in such an activity with the end result being a monopoly of the bay bottom with little or no public bottom. Their feeling extends from a strong belief that the seas, or estuary in this case, are a common property resource belonging to everyone. They have a right to tong oysters just like their fathers and grandfathers had done. Bowden (1981) has stated that the single most important public policy question raised by mariculture is that of whether private property should be created in the sea. Presently, state statute (370.16(9)) prohibits shellfish leases in Franklin County. Franklin County is the only county in the state where leases are prohibited and some feel like this is an inequitable statute and may, in fact, be unconstitutional.

Presently, once a lease is acquired, it remains the property of the leaseholder as long as the lease fee and lease agreement are met each year. The agreement may stipulate the type, shape, depth, size and height of cultch. By the end of the second year from commencement of the lease, one fourth of the water bottom leased shall be placed under cultivation. One fourth shall be put into production each successive year until the entire lease is under cultivation. This is nearly impossible for the DNR to check or enforce and as a result many leases in the state have never been fully cultivated. Leases may also be sold or transferred which makes the fear of monopoly very real.

The biggest problem with leases seems to be greed and theft. Obtaining a lease solely for the purpose of controlling that bottom without culturing it, is not the way the system was intended to work. Stealing oysters from a leased area is difficult to stop and requires the leaseholder to employ a watchman. Poached oysters are a lost revenue which drives up the cost of production. Too much poaching could put a leaseholder out of business and at present, the only legal remedy is to charge the poacher with trespassing. Since the fines are small, poaching on leases is profitable.

On the other side of the coin, leaseholders have been known to remove oysters from state bottoms, bring the oysters to the lease site, then either plant or cull the oysters over the lease and claim the oysters came from the lease. A person could obtain a lease and not work it, but instead steal from the state and cull over the lease. Oysters may even be taken from closed areas and then sold as leased oysters. A leaseholder operating legitimately might work his crew on state bottoms when these waters are producing well, then work his lease when state bottoms are not producing well which creates an unfair situation for the oystermen only working public bars.

Most oystermen believe the cost of developing a lease is unobtainable for the common man. They fear that lease monopolies would result in a loss of independence for the oystermen and they would end up working for the leaseholder rather than have their own business.

2. The Case for Leasing

A number of states have active shellfish leasing programs which have benefitted the local oyster industry. Louisiana has over 240,000 acres of leased oyster beds. Up to 100 acres per person may be leased in Mississippi waters. In South Carolina leases are divided into quadrants which are then cultivated on a rotating basis with harvest occuring once every fourth year per quadrant. The majority of oysters presently shucked in Apalachicola are trucked in from natural beds in Texas and leased beds in Louisiana. The economic benefits leasing has brought to other states should certainly be thoroughly examined and their feasibility for implementation in Florida waters be established.

Basically, a leaseholder should be considered the same as a farmer trying to raise a crop for a profit. This differs considerably from the oysterman who presently hunts and gathers from the wild. Farmers have always been stewards of the land they farm as they must continue to make that land produce year after year. If the oyster farmer utilizes the resource correctly, then it will always produce. Leases could benefit the public bars and the oystermen who fish the public bars by relieving some of the fishing pressure from the public bars, by extending markets, by creating new markets, by obtaining higher prices for leased oysters, and by helping to protect the resource by creating new oyster beds which will also provide habitat for other estuarine organisms.

The case for leasing, and mariculture development in general, is based upon a number of arguments. Wild stocks are finite while demand is increasing which results in increased fishing pressure on the resource. The decrease in the size of the average oyster harvested in Apalachicola Bay directly supports this argument.

While cultured oysters will not replace the natural fishery, they will supplement the supply of marketable oysters. Apalachicola Bay is considered to be one of the most pristine and relatively clean estuaries remaining in the country. This is one of the reasons why shellfish thrive in the bay. However, incresing threats from pollution stemming from development, runoff and upstream sources of discharges, will eventually restrict approved shellfish harvesting areas. Producing more oysters on less available area can be accomplished through leasing. Mariculture offers increased yields per acre through culture techniques, breeding programs, and effective management. Leasing will also result in more efficient harvesting. Less time will be spent searching for the catch as the culturist will know which areas are producing best at different times of the year.

Mariculture techniques applied to oyster leases will result in an improved, higher quality product, more consistent in flavor and texture. The culturist eliminates overcrowding which allows quicker and more uniform growth requiring less shucking time and bringing a higher price. Quality is insured by management resulting in a product which can proudly be declared as grown in Apalachicola. Satisfying the supply and demand of markets is the best argument in favor of leasing. Leasing can provide a continuous and regular production which will result in regular deliveries to established markets. This in turn, will establish a good reputation for the producer resulting in the acquisition of new markets.

Management and planning are the keys to a successful lease. For example, a producer may require 300-400 bags (bushels) of oysters each week to satisfy established customers on a year round basis. The producers business plan will reflect this figure and the lease developed so that a minimum of 400 bushels per week are produced or an equivalent number of bushels (20,000) produced per year. The oysters may be harvested on a weekly basis or harvested during the best producing months and then frozen, or harvested using a combination of factors. In any event, the culturist can identify the needs necessary to satisfy markets, develop a business plan to meet these needs, and effectively implement the plan in the development and working of the lease operation.

Leasing will also help preserve the resource if good management practices are followed. A leaseholder must build oyster reefs. The reef will increase suitable substrate for spat settlement and eventually reproduction. Other reef organisms will flourish including juvenile shrimp, trout and flounder, adding to the overall productivity of the nursery grounds. Recreational fishing would be a compatible use of the leased area. The leaseholder can also control harvesting on the lease. Only the correct size will be harvested and proper culling employed. Oystermen working the lease who do not employ proper techniques will not be allowed to continue working the lease. Oystermen would be expected to properly work the lease because they can harvest twice as many oysters from leased bottoms as opposed to public bottoms in the same amount of time.

The case for leasing in Apalachicola Bay has met heavy resistance in the past. Any future possibility of re-opening the bay to leasing would have to equitably consider monoplies, maximum lease acreage, ownership and transfer of lease title, methods of harvesting the lease, protection of public bars and the small individual businessmen they support, and poaching from both private and public grounds. Leases must be equitable so that the small entrepreneur or individual oyster tonger may participate in the lease program. Low cost loans with deferred interest or government development grants may be necessary to insure participation by individual oystermen.

Individual or family leases should be strictly controlled. Hypothetically, these leases should be limited to 10 acres of bare bottom with a four year period to develop the lease. At the end of the four years, the leaseholder should have the option to lease an additional 10 acres. A fully developed twenty acres could provide a family with a very high standard of living and should be a maximum ceiling for an individual lease. In this scenario there would be no selling or subleasing of the lease. However, the lease should be allowed to be passed on (inherited) to an immediate family member. In any event, if the lease is not properly developed, abandoned or no longer harvested, or the leaseholder dies without passing it on, the lease should revert back to the state and become public bottom, never to be leased again unless it is barren. Larger leases may be granted to corporations, oyster dealers or cooperatives under much stricter conditions with maximum acreages set and titles which revert back to the state upon termination of the lease. One approach would be to set aside a "pool" of available acreage for leasing specifying acreage ceilings for various user categories. Another possibility would be to develop leases in deeper areas of the bay where tongers do not work. Franklin county residents should have first priority for obtaining a lease. Poaching laws should be strictly enforced and penalties made more severe. If additional harvest labor is needed, leaseholders should be required to subcontract the harvest work out to private oystermen at the current going rate per bushel. Any lease resembling a monopoly should be strictly prohibited, except for an oystermen's cooperative which should be specifically established by law.

Once a comprehensive program is developed, an educational program should be implemented to inform and advise residents of the county as to the advantages and disadvantages of the leasing program. As a first step, the state should consider entering into a cooperative venture with a private leaseholder in Apalachicola Bay to develop a small acreage demonstration project showing various culture techniques, production processes, and economic analysis.

3. Individual Oyster Lease Approach

The strong independence of the individual oyster harvester demands that any changes in current practices of the industry benefit the small guy so as not to generate local opposition. One approach to increase productivity of the bay and maintain the resource would be to offer small leases to individuals. This section examines the income needs of an individual tonger, the operation of a 10 acre lease, and the costs and returns of the 10 acre lease.

The income of individual oystermen is difficult to determine since nearly all transactions are cash. An estimation may be made by looking at the average daily catch, which most estimate as between 15 and 20 bushels of oysters. However, daily catch varies with the ability of the individual to harvest effectively, the numbers of hours spent harvesting, the amount of culling, and the individual's respect for the resource. One harvester may tong and cull 15 bushels of standard oysters a day while another may tong in the hole 40 or more bushels of unculled and undersized oysters each day and earn considerably more money while harming the resource. Price also varies with demand and size of the oysters harvested. Harvesters sell their catch to local oyster houses, trucks illegally buying oysters, or a direct market developed by that individual. The following matrix indicates the potential gross daily earnings of an oysterman:

	Bushels Harvested per Day						
Price/Bu	10	15	20	25	30	35	40
$5.00	$50	$75	$100	$125	$150	$175	$200
5.50	55	83	110	138	165	193	220
6.00	60	90	120	150	180	210	240
6.50	65	98	130	163	195	228	260
7.00	70	105	140	175	210	245	280

An oysterman who worked 160 days and tonged twenty bags a day would gross $17,600 a year at $5.50 per bushel or $22,000 a year if he worked 200 days. A tonger could potentially gross as much as $56,000 ayear at $7 per bushel, 200 working days, and 40 bushels harvested per day. A more realistic figure may be derived at by assuming the average tonger works 3-4 days per week for 39 weeks a year (9 months) and averages 20 bags per working day which is roughly $15,000 per year at $5.50 per bushel (2730 bushels total). The question then arises as to the size of a lease necessary to support the oysterman and his family.

Ideally, if an acre of naked bottom is evenly spread with cultch, sown with seed, and managed properly, then the acre can theoretically produce 1200 bushels of oysters per year assuming a 25% mortality (See Appendix A for calculation). To earn $15,000 per year, an individual would only need 2.5 acres of good producing reef. However, in order to obtain a slight economy of scale and higher income, a lease of 10 acres was chosen. It was assumed the lease would be worked by a family with additional help hired if needed. The family would utilize the same equipment used on a public bar and have roughly the same annual expenses, except for those costs charged to lease maintenance and development. Interest was estimated at $99 per $1000 borrowed at 15% on a 10 year note. A selling price of $5.50 per bushel was used. A summary of costs are presented in Tables 4 and 5.

The operating and development budgets should only be used as guides in developing a business plan or preparing a loan application. Interests rates will vary with the type of loan, the duration of loan and the present cost of money.

To maintain cash flow until the crop is harvested an operating loan may have a much different rate and payback period than a capital loan to develop the lease. The artificially created reef is only depreciated over 20 years, but will exist, essentially, forever. Depreciation could therefore take place over a much greater length of time. Ideally, there should be a 30 month lag period between the time the reef is constructed to the time the first oysters are harvested. Interest on the development loan must be paid during this period and this budget does not account for that interest and additional funds that would have to be obtained to meet the lag period obligation. If coon oysters are relayed or larger seed oysters planted on the reef or a

TABLE 4
10 Acre Oyster Lease Annual Operating Budget

	Cost	Life Span	Annual Cost
Equipment (fixed)			
Boat - 22 ft wood, 30 yr frame guarantee	1,200	20	60
Motor - 40 HP Mariner with stainless steel prop, tank & hose	2,100	7	300
Interest			327
Subtotal			687
Lease development			
Materials, spreading, marking	64,671	20	3,234
Interest			6,402
Subtotal			9,636
Expenses (variable)			
Gas/oil (4 gal/day)-(1.25/gal) (200 days)			1,000
Tongs, cull tools			125
Maintenance & repairs-paint, dry boat; plugs, grease, etc			250
Permit/lease fees-(5/ac)(10/ac) + (25 license)			75
Misc. Supplies			150
Taxes and Insurance (estimated)			800
Lease Maintenance (175-225 cu yd shell, gas, etc.)			2,000
Interest			436
Subtotal			4,836
TOTAL			15,159
Annual Returns (Gross)			
(1200 bu/ac)(10ac)(5.50/bu)			66,000
(1000 bu/ac)(10ac)(5.50/bu)			55,000
(800 bu/ac)(10ac)(5.50/bu)			44,000
(600 bu/ac)(10ac)(5.50/bu)			33,000

TABLE 5

Lease Development Budget[1]

	Cost
Shell - 8067 cu yd at $7.25/yd	$58,486
Spreading cultch	
haul/load shell on barge (275/day)(3 days)	825
Barge 110'x30'x6' (75/day)(3 days)	225
Boat 50'x 20' (1200/day)(3 days)	3,600
Fuel and Oil (80/day)(3 days)	240
Hose and Pump - 3" suction, 100 psi, 160 gal/min (125/day)(3 days)	375
Labor - (2 men)(60/day)(4 days)	420
Marking lease - Poles, bouys, cable, rope, signs	500
TOTAL COST	$64,671

1. Notes - Shell cultch is assumed to be purchased locally. Otherwise shell must be barged from New Orleans at $14/yd delivered on a deck barge with a 2500 cu yd capacity weighing 2125 tons. The shell is enough to evenly spread a 0.5 foot layer of cultch over 10 acres. The operation may be completed in 3 days, loading the barge in the evening hours and spreading cultch from the barge during the day. The barge could be purchased used for $60,000 and the boat $80,000 (twin screw, 671 detroit diesels). The boat charge includes captain and crew. The pump costs $1155 new fob St. Louis and is smaller than the pump used by the DNR, but sufficient according to the manufacturer. Rent on a pump, dump truck and loader was estimated from conversations with

private contractors. The extra days labor is for marking the lease using the leaseholders boat.

portion of the reef, the lag period could be reduced to as little as 12 months and cash flow initiated that much sooner. Adequate collateral for the loan may pose another problem especially since in this scenario the lease could not be sold or sub-leased.

The boat selected is the standard wooden oyster boat. The boat is built locally to individual specifications and has a 30 year guarantee on the frame. The builder claims that with annual painting and maintenance, the boat could last this long. However, with a lease, a larger boat may prove more practical. Mechanical harvesting would require a larger working area for culling and the larger boat would be more suitable in maintenance shelling the lease each year. The scenario calls for an oyster reef six inches thick. This may not be enough cultch to properly construct a reef which would add to capital requirements and higher interest payments. Many reefs are constructed a foot or more off the ground. The three day time period may also be insufficient to adequately build a reef and would add to lease development costs. The 806 cu yd per acre of cultch is much greater than the DNR average of 254 cu yd per acre and should produce a much better constructed reef. Ingle (1962) estimated 746 cubic yards per acre to be sufficient, but did not specify thickness of the reef.

The lease could produce as much as 12,000 bushels of oysters per year. An individual with good oystering skills might harvest a maximum of 5000-8000 bushels during the year. The remaining bushels would have to be harvested by outside help. In a family operation, the additional oysters might be harvested by other family members, but at a minimum would require a second boat. Hired labor would, most likely, have to be paid the going rate they could earn by tonging the public bars. One successful lease holder solved this problem, by only allowing the harvest of select oysters but paying the standard bushel price. The difference between the standard and select price was used to pay for the lease expenses plus a profit. The leaseholder stated the harvesters did not complain as they could tong two times as many oysters on his lease in the same amount of time as they could from public bars.

Annual returns were calculated for production of 600, 800, 1000, and 1200 bu/ac. The $15,000 income figure generated earlier can easily be met with 600 bu/ac production. The break even point may be reached at 275 bu/ac/yr. Anything over 800 bu/ac/yr would provide a family with a high standard of living. At the high end of production, total gross income would pay for the entire initial cost of the lease development. Profits such as these should interest a wide range of investors. Additional profits could be earned by carrying production through shucking and to market.

The 10 acre lease scenario appears to be economically feasible despite the model's limitations. Once built and properly maintained, the lease will continue to earn profits. Securing the capital, wading through the regulatory process, and waiting out the time period until oysters can be harvested are the major risks to such an undertaking. Proper management, predation and diseases, and protecting the lease from poachers are the major problems to consider once the lease is producing. Selling and implementing this type of program would most likely meet with much local opposition. The reason is primarily sociological, going back to the prevailing attitudes of leave things as they are and fear of change.

The $65,000 cost of developing the lease would frighten the average oysterman away as there is almost no risk in tonging the free public bars. Making payments on a loan to develop something which may be obtained for free does not make sense to the average oysterman even if interest payments on borrowed capital can be deferred. Creating a community awareness of the resource depletion, and methodologies, including leases, of protecting and enhancing the resource, are the first steps which must be taken to solve the problem and alter the present attitudes of local residents.

The next recommended step to implementing the small scale individual lease program is to form a joint venture between the public and private sectors. The government wants to protect and enhance the resource by building artificial reefs which will have an added economic benefit of supplying more oysters for the industry and keeping local residents employed. The private individual shares the conservation concepts, but must continue to exploit the resource in order to earn a living. The state could set up and manage the program. Leases would be granted under strict development and conservation conditions with guidelines vigorously enforced. A loan program would be established by the state for development of the lease site. Loans would be strictly administered to insure the funds were expended on cultch and lease development. Loans should be long term with adjustable interest rates and have a 30 month deferred period before payment of the first installment to allow the leaseholder time to culture and begin harvesting oysters.

Allowing the state flexibility in altering lease fees and interest rates would assure the state of receiving a fair return once the lease was actively producing oysters. Failure by the leaseholder to properly develop and work the lease or forfeit on loan payments would automatically revert the lease back into state ownership. The state could then finish reef construction if necessary, but ultimately turn the lease area into a public bar. A certain percentage of leaseholders are bound to fail and these leases would satisfy the state goal of creating more public reefs. A comparison of costs between this proposed program and the present DNR program was not attempted. The state would also be required to have an oyster expert on site who would assist leaseholders in developing and managing their oyster leases. The benefits to the private individual lie in ownership of their own oyster bar which will increase income, provide long term security, and assist in protecting the resource.

4. Cooperative Oyster Lease Approach

An alternative to the individual lease approach is to develop a large lease operated by a non-profit cooperative. The cooperative should function similar to a private lease and produce the same economic benefits. In order for the concept to work, there must be sufficient interest and ability of local residents to develop and manage the cooperative. This does not seem to presently be the case in Franklin County. Once again the solution may be found in a marriage between government and the private sector.

Today there are two aquaculture cooperatives which may be examined for comparison with the Franklin County situation. The largest processor of farm raised catfish in the country is a farmer owned cooperative in Mississippi. It is set up as an agricultural cooperative, similar to most farmer cooperatives and is less than 20 years old. The cooperative is 100% member owned (113 members) and has no ties with government. Capital has been generated from members and commercial sources. The cooperative is vertically integrated operating its own feed mills, processing plants, distribution system, and buying fish from its members. The cooperative processes and markets 1 to 1.5 million lbs of live fish each week grown by its members. This type of structure, although ideal from a private sector viewpoint, would probably not work in Franklin County due to the sociological factors previously stated.

A structure much more applicable to Franklin County may be found in Alaska. The Alaskan Legislature passed extensive legislation during the 1970's to create private non profit regional aquaculture associations. The intent of the legislation is to authorize the private ownership of salmon hatcheries and facilities by private nonprofit corporations for the purpose of contributing, by artificial means, to the rehabilitation of the state's depleted and depressed salmon fishery. The laws designate specific regions of the state for salmon production and authorizes the establishment of regional associations to develop comprehensive plans in conjunction with state planning councils and to manage and operate the salmon facilities development in the plan. The legislation is designed to give commercial fishermen a strong voice in the development of the resource.

User groups are defined and the plans must assess their needs and aspirations. The regional associations are run by a Board of Directors composed of at least one representative from each user group with most members being commercial fishermen. The commercial fishermen board members are elected by the membership of the gear groups they represent (seine, power troll, gillnet and hand troll). Other board representatives include sports fishermen, native Indians, chamber of commerce, subsistence fishermen, processors, municipalities, and public at large. The board sets policy, suggest programs, and approves expenditures. Association staff are directly responsible to the commercial fishermen through a chain of command.

The regional plans must encourage investment by private enterprise in the technological development and economic utilizations of the fisheries resource. The plan must address numerous criteria including harvest management, natural stock considerations, hatchery and harvesting site evaluations, stock genetics, control of diseases, transportation of live organisms, sale of hatchery fish, legal harvest gear, sharing an allocated harvest area, broodstock, program compliance, annual reports, and additional benefits derived from the program such as employment, education, training, and research. The state assists, as much as practically possible, in the planning, construction and operation of the facilities.

The Alaskan laws provide checks and balances through the planning and permitting process. Permits contain specific conditions pertaining to criteria such as harvesting, management, health of organisms, and segregation of cultured and wild stocks. The legislature has made low interest loans available for planning, construction and operation of the facilities. The interest on the principal is deferred and does not accrue during the intial period of the loan which may be 5-10 years in length. Funds originate from fossil fuel revenues to the state which are dedicated to development and enhancement of renewable resources. Operating capital is also generated by a mandatory 3% assessment of the total catch of permitted commercial fishermen. The tax is collected by the buyer of the catch who in turn is responsible to the state.

The end result is the development of hatcheries cooperatively owned and operated by commercial fishermen. Staff hired to operate and manage facilities may number over twenty, providing another economic benefit. The success of the associations have been verified by an extensive tagging and analysis program conducted by the associations and the state. Nearly all the associations presently are or are projected to be operating in the black and making loan repayments. Revenue is generated from the 3% assessment and sale of surplus fish returning to the hatcheries. The so called profits are pumped back into the operations to hire more staff, expand facilities and develop new programs. The associations have shattered egg take records and return records most every year. Return rates by the non profits have far exceeded return rates for private ocean ranching operations in Oregon demonstrating the success of the Alaska program. Commercial fishermen are catching more fish and earning more profits. Conflicts of gear user groups have been resolved by allocation of gear days for specific sites with order being determined by lottery. Overall success is due to the interest of commercial fishermen who have demonstrated a lot of forethought in planning and executing their association.

An oyster cooperative in Franklin County could be set up using the Alaskan laws, regional plans, and associations as generalized models. State involvement would be necessary to coordinate plan development, organize and initially operate and manage the cooperative. The state should also provide a full time oyster culturist to assist coop members in developing bars, maximizing production, and trouble shooting problems. The plan might call for a gradual phase out of state involvement. However, the state should maintain a close relationship through a regulatory process, especially for financial matters, to insure payback of loans and a fair return to the taxpayers for rent on the lease. The recommended approach is to detail the structure of such a program in legislation directed at the oyster industry.

A schematic scenario of one such possible government/private non profit joint venture is diagramed in Figure 5. The Legislature would create a private non profit Apalachicola Regional Fisheries Association (ARFA) to develop, rehabilitate and enhance Apalachicola Bays declining and depressed fisheries through a program designed to protect both the integrity of the estuary and insure the long term success of its fisheries. The Board of Directors would be composed of oystermen, shuckers, dealers, bay shrimpers, other commercial fishermen, recreational fishermen, chairman of the county commission, community persons, etc. to plan, develop and execute <u>their</u> association and protect <u>their</u> resource. Direct input, organization and membership could be provided by the Oyster Dealers Association and the Franklin County Seafood Workers Association. The ARFA mandate would be to develop a comprehensive plan for long term management of the fishery resources. The central vehicle for coordinating all public assistance, state and federal agencies, and organization

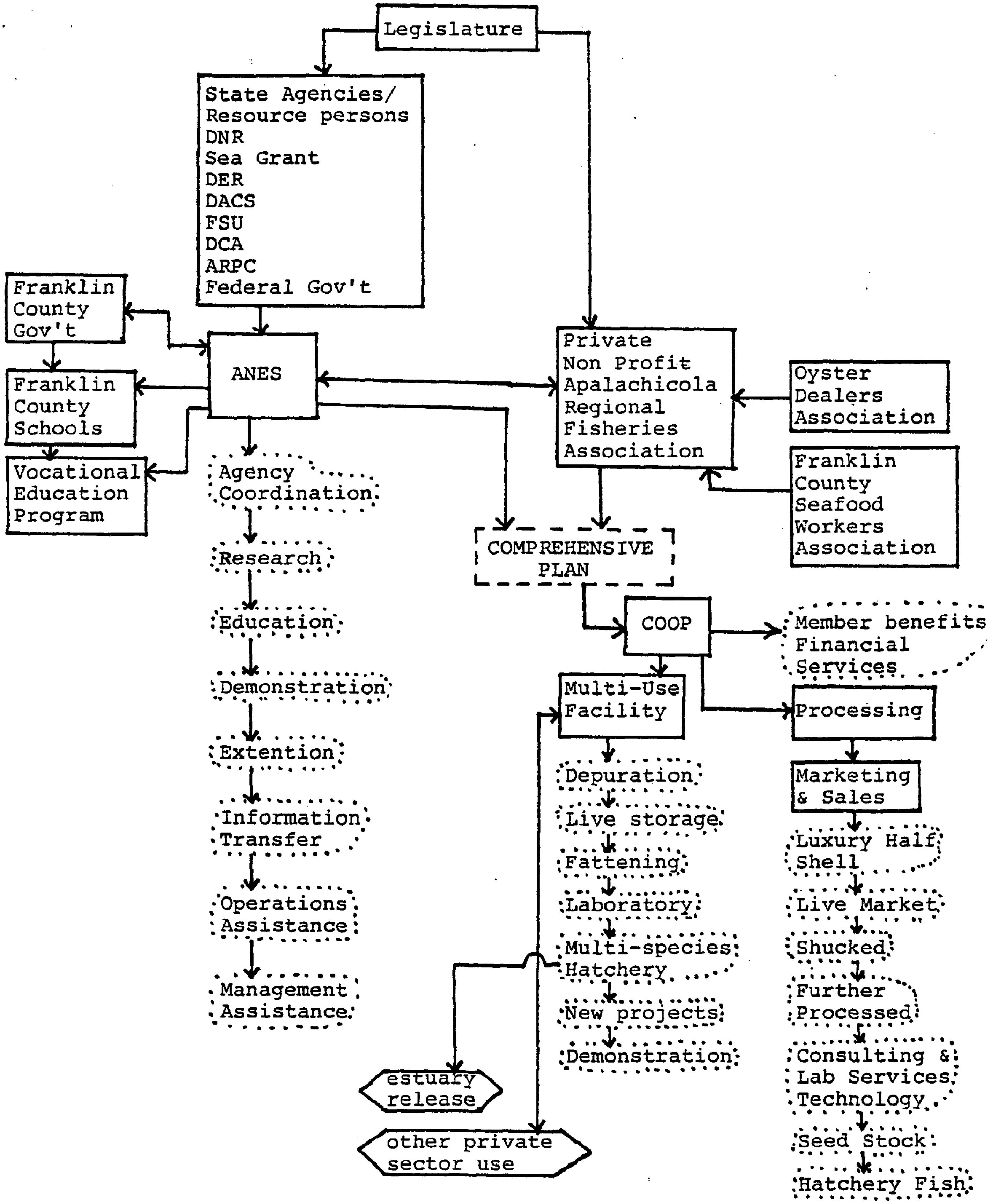

FIGURE 5
DEVELOPMENT OF A FISHERIES ASSOCIATION PLAN

and managemnt assistance to ARFA should be ANES. ANES would be responsible for coordinating the development of the plan with the Association and implementing the plans recommendations. A gradual phase out of ANES to an advisory role would be expected over time.

One vehicle to developing a cooperative would be to utilize the Apalachicola Regional Fisheries Association. The Association could form a private non profit service corporation to act as the cooperative. Since membership to the ARFA would be open to all persons working in the seafood industry (i.e. Seafood Workers Association, etc), the service corporation would be owned by association members and corporate staff would be responsible to the Association Board of Directors. This is an equitable approach with a good chance of community acceptance especially if there is a push from government. The cooperative should sub-contract with its members for harvesting the lease, with a variable quota rate dependent upon production estimations and the number of members actively working the lease. This would preserve the independent small businessman attitude of the oystermen.

Management of the cooperative should have control over the time of year a segment of the lease is harvested, the size of oysters to be harvested, harvesting methods, and the number of oystermen working a segment. All harvested oysters would be sold back to the cooperative. The burden of all management should be the responsibility of coop staff. The coop will control all sales, purchases, disbursements, and records in order to provide a big business type service and capability to the member oystermen. Operation of the coop could then be centered around a computerized system of management accounting. Additional work, other than harvesting, done by members on the lease, such as general maintenance, culling and relaying, would be debited or credited to individual member accounts and paid at a later date or in the form of a dividend. The coop should be responsible to provide at a minimum: training and technical production services; reduce materials cost through volume purchasing; provide an equipment warehouse facility; monitor crop growth; organize and schedule member based labor pools; and schedule production harvesting and processing for consistent volume output and sales. As the coop expands and establishes a sound business record, additional services can be provided to members such as group insurance, health plans, retirement plans and loans. In fact, the coop could provide financial planning to individual members to insure a regular cash flow throughout the year including those times when the bay is closed to oystering. This service could reduce public subsidies in the form of unemployment and welfare payments.

Financing the entire operation can be accomplished by a number of methods or combination of funding sources including government grants, low interest government loans, private loans from banks or production credit association, private capital, or direct assessments on oyster catches. Initial planning followed by construction of artificial reefs and production facilities would be best accomplished by a combination of grants and low interest loans with deferred payments. Generating capital for the long term could come from assessment on oyster catches and vertical integration by the cooperative. Vertical integration would require the coop to carry production from spat to market. This would require the coop to develop processing and marketing expertise and is highly recommended. After purchasing oysters from coop members working the lease, the cooperative could process the oysters into different products such as fresh in the shell, shucked in the pint and gallon, frozen, or further processed, to service diverse markets. The markets should include a luxury half shell trade to fine restaurants in large cities year round as well as fish distributors, institutional markets, and retail food stores. Monies earned from processing, distribution and marketing oysters would be used to pay overhead including staff salaries, repayment of loans, expansion of facilities, development of new projects, and perhaps even dividends to members. A processing facility would have to be leased, purchased or designed and constructed. Equipment for the processing plant, refrigeration and freezers, and trucks for distribution would have to be purchased. A detailed operating budget, equipment and facility needs would be a part of the comprehensive plan developed to establish the cooperative's feasibility.

New projects could include off bottom culture techniques, diversification into the culture of other organisms, an oyster canning plant or oyster breading plant which would also require the development of new markets, and a multi-use facility. A multi-use facility is highly recommended and might be included as part of the initial operation. The multi-use facility should be designed to include oyster fattening, shellfish depuration, live storage for shellfish, crab shedding, hatchery, and research and laboratory functions. The fattening, holding and depurating functions would insure the supply of oysters for a year round luxury market. Oysters could be depurated during times of bay closures or shellfish could be brought in from elsewhere for depuration. Depuration is an issue the county might have to address in the near future if pollution sources are not brought under control and water quality in the bay declines. Holding oysters and clams in a live condition would assist in supplying certain lucrative markets. Crab shedding could occur during those times of the year when the facility had low usage or when the markets for soft shell crabs are the best. A low cost hatchery as described in the section on hatchery technology, could serve to produce hybrid oysters, cultchless spat for tray culture, or as an emergency back up system in the event of a failure of natural setting in the bay. The hatchery might be redesigned to be sophisticated enough to be utilized to spawn other commercially important species for direct sale or future growout. The research laboratory could function to monitor water quality, develop hybrid oysters or other organisms in combination with the hatchery, explore new culture techniques or examine new species for culture potential. All uses could be housed in a single facility as many of the uses would require the same basic equipment, tanks, and plumbing. The old oyster fattening facility at Nine Mile could be used as a model from which to improve upon. Detailed design, equipment needs and costs of such a multi-use facility would be developed as part of the comprehensive plan. A site along St. Vincent Sound or St. George Sound should be considered as good water quality and higher salinities are important in producing a high quality oyster.

The cost of establishing a cooperative would be high. A minimum of 100 members and 1000 acres of leased bottom is recommended. Building a thousand acres of reef would be no easy task and may take as long as 3-4 summer seasons to complete. Alternative construction schedules should be considered. The majority of the cultch would most likely be barged in from Louisiana at $14 per cubic yard delivered, considerably driving up the cost per acre. Total cost of reef building and facilities could easily exceed $10 million. However, ingenuity by coop members could help save money. This would include the use of members equipment, pooling of labor, and working around the clock in shifts to achieve maximum efficiency in the use of leased equipment for reef construction.

In any event, the comprehensive plan should lay out a workable time table for lease development correlated with production, marketing, and cash flow. Such a comprehensive plan would become the business plan for the cooperative. Oyster production on 1000 acres could reach as much as 1,200,000 bushels per year. At a selling price of $23 per gallon, the cooperative could theoretically earn $23,000,000 per year. At this rate loans could easily be paid off and member earnings soar. The feasibility of a cooperative should certainly be investigated further as part of the comprehensive plan.

N. Summary and Recommendations

Apalachicola Bay is a gold mine which has never been fully exploited. Sociological factors have largely kept the industry from modernizing and progressing to reach its full potential. Pollution from sewage, runoff, urban development, and upstream users is threatening the resource. Oystering is presently a primitive hunting and gathering technique, but earning income for over 1100 residents in the county. However, oysters are being overfished and the resource is declining. Poor enforcement of laws has only worsened the situation. The net results are an unstable economy and an ill managed resource. Biologically there is nothing really wrong with the oyster population as it is very fecund, has few pests and diseases, and has excellent water quality for oyster growth. The solution to the problem requires a combination of economical and biological factors along with close cooperation by all those employed in the industry, other residents in the county, and government.

Some recommendations were presented in the sections on the Marine Patrol and research needs. A number of recommendations are presented here for careful consideration by Franklin County residents and government agencies. The recommendations are not ranked in any particular order.

1. Artificial Reef Construction - A comprehensive analysis should be undertaken on existing artifical reefs to determine which reef construction method(s) have resulted in the greatest annual production and the best long term production. A research program demonstrating various new and existing reef construction methods and monitoring environmental factors correlated with community settlement, succession, and climax should be undertaken under the guidance of the Sanctuary. The best methodology would then be utilized in future reef construction. A part of the analysis should include an independent CPA cost accounting to determine the real cost of reef construction. The reef program should then be expanded both publically and privately. Methods to pay for the program should be examined including private sector involvement. The program should include the sprinkling of clean bleached shell on existing reefs and the possible renovation of older nonproducing bars.

2. Productivity of Bay - The biotic potential for oysters in Apalachicola Bay should be thoroughly evaluated. At a minimum, the analysis should include the maximum number of oysters the bay could reasonably support, the total acreage suitable for reef construction, and the effects, both positive and negative, of expanded oyster production on the ecology of other organisms residing in the estuary.

3. <u>Communication and Cooperation</u> - A coalition coordinated by ANES of Seafood Workers Association members, Oyster Dealers Association members, other county residents, the Marine Patrol, and government agencies should be organized to ferret out those who are abusing the resource by harvesting undersized oysters, tonging in the hole, or buying undersized oysters. Oystermen could use peer pressure to reduce illegal activities. Dealers could do the same to prevent the buying of undersized oysters. The Marine Patrol should have more leeway and flexibility in enforcing the law so that the law may be vigorously enforced against those abusing it the most. The coalition could then serve as a vehicle to set new policies for enhancement and preservation of the resource (i.e. Apalachicola Regional Fisheries Association).

4. <u>Education</u> - A comprehensive education program and public relations compaign is recommended as the long term solution to resource management in the bay. Children educated in oyster biology, production techniques, and management strategies will grow up with sufficient respect for the resource to exploit it wisely over time. Educating existing residents, especially those new to the county (such as St. George Island residents), to the benefits and importance of the oyster industry should result in an informed constituency dedicated to the conservation and wise use of the oyster resource. Government agencies, especially those with Coastal Zone Management responsibilities and policies and planning agencies, will require a broader understanding of the

oyster industry and the importance of a clean environment to the continuance of the resource.

5. Production - Increases in production may be achieved through improved management techniques including the harvest of larger oysters, increased culling, replacement of cultch, modernization of equipment, and development of leases. A new program to lease naked bay bottom to individual oystermen, an oystermens cooperative, and/or private companies should be well designed and implemented. It should minimally include provisions to prevent monopolies, protect public bars, maintain the existence of the independent oystermen, and encourage private sector participation. The feasibility of an oystermen cooperative should be examined and if established, a comprehensive plan developed. Off bottom culture techniques should be developed suitable to various parts of the bay. A demonstration project should be undertaken by the state on an existing private lease to develop maximum production, show new culture techniques and provide economic information. A low interest government loan program with deferred interest payments, should be developed to finance individual and cooperative leases.

6. Harvesting - Harvesting technology should be upgraded to remain competitive with other oyster producing areas with mechanization. New methods should be tested and evaluated in the areas of labor savings, volume output, economics of the process, and environmental acceptance.

7. Technical Assistance - A full time oyster expert should be hired by the state and reside in Franklin County. The person would act as an extention agent to assist in development of leases and artificial reefs, provide production and harvesting assistance, transfer information, and act as an advocate for the oyster industry with government.

8. Economic - Data should be collected on the price and market demand for oysters now and projected into the future. Annual earnings of oystermen should be established. Total production and value of both Apalachicola oysters and those trucked in from other states should be tabulated. Lending institutions should be educated on the value and potential of oyster culture operations. Private and public funding sources need to be identified.

9. Marketing - A complete review of the Apalachicola oyster industry's market structure should be undertaken. New markets need to be developed including a luxury market for select half shell oysters known for being grown in Apalachicola Bay. New product forms should be developed and promoted. Consumers should be educated as to the nutritional value of oysters and ways to prepare and serve oysters.

10. Health - Coliform testing needs to be improved for more rapid and frequent detection to prevent disease outbreaks. In addition, new methods or new organisms besides fecal coliform need to be developed to evaluate the water. When the bay is closed,

testing should be done more often and with more samples so as to re-open the bay at the earliest moment.

11. Government - Planning is needed to restrict development and resolve multiple use conflicts. Apalachicola Bay should be designated as an oyster producing area. Measures should be enacted to protect oyster habitat and to allocate space for oyster production which will be forever free from environmental alterations by man.

VIII. SITING

Terrestrial farming requires access to arable lands. Aquaculture or aquatic farming also requires access to lands and waters suited for its purposes. For mariculture to develop in Franklin County, access to lands or waters in or bordering the Apalachicola Bay system is critical. The limited supply of such lands, the competing uses for this area by several different user groups, and public ownership of all submerged lands make siting a mariculture project in Apalachicola Bay a difficult task. These constraints will be explored in the section on the regulatory process. This section ignores the regulatory constraints and focuses on potential sites throughout the system.

Determination of sites was accomplished by examination of a variety of maps of the bay, biological considerations of potential species, interviews with local citizens, and field observations. On one field observation (7/9/84), temperature, salinity, dissolved oxygen and depth were recorded. The values are not to be considered truly representative, as data would have to be collected over time and seasons to be useful in assessing the full potential of a particular site. However, the values are useful as preliminary indicators of a sites potential, and for this reason are reported.

Upland pond sites for mariculture are limited in Franklin County primarily by long-term private and public ownership of the majority of the potential acreage. St. Vincent Island is a federal preserve and aquaculture is not a purpose of the preserve.

Little St. George Island is a state park and presently cannot be used for commercial purposes. St. George Island is well suited for a number of aquaculture activities on the bay side. However, developmental pressure eliminates the island from consideration. Land adjacent to St. George Sound is primarily residential and further constrained by U.S. 98 which runs along less than 200 feet from the waters edge. Constructing ponds north of the highway where housing is absent requires placing water intake lines beneath the highway adding an additional, and possibly prohibitive, expense to a commercial venture. This area is slowly developing with low density residential units which place a higher value on the land and greater return on investment, and as such can be ruled out. Lands bordering East Bay are primarily marsh and wetlands. Poor accessibility, low salinities and inclusion of most of the acreage as part of the sanctuary limit their potential for pond development. A small stretch on the western shores of East Bay and north of Eastpoint may be suitable for pond culture, but was not inspected.

The only sites remaining are located along the north shore of St. Vincent Sound. There are approximately 1000 acres of suitable pond sites located between the sound and Highway 98 and S.R. 30. A fringe of wetlands exist along a portion of the approximately 15 mile stretch, however, the majority are uplands with much of the edge dropping off directly into the sound. Nearly all the acreage is owned by St. Joe Paper Company and is planted in pine. The value of such land is difficult to estimate since slash pine requires 18 years to mature. At an average growth rate of one cord per acre per year over 18 years and today's average value of $25/cord, the value of slash pine may be estimated at $450/acre/year. An intensive mariculture operation culturing fish or shrimp could easily gross between $2000-$6000 per surface area of water per year.

Most of the soil is believed to be Leon Fine Sand which consists of a light-gray, fine textured sand grading at 8-12 inches into a lighter colored fine sand. About 15 to 18 inches in depth a dark brown layer consisting of organic matter mixed with fine sand and some iron compounds known as hardpan is found. The hardpan layer varies in thickness from 2 to 12 inches or more and inhibits the upward or downward movement of water. Soils which contain hardpan are not as suitable for pond construction as soils containing clay since water will have to be added more frequently during the dry season. Ponds constructed in hardpan soils are not true levee ponds, but more like a shallow water table or dugout pond where the hardpan is mostly left on the bottom of the pond and the overburden is spread around the banks to protect against flooding. Such ponds are drainable either through use of the natural topography or by digging a drainage ditch deeper than the pond.

The salinity of St. Vincent Sound varies considerably over the year and may range from 5-30 ppt. In general, the salinity increases towards Indian Pass. Salinities are usually lower from December through April when river flow is highest and increase during late summer and fall when river flow is lowest. The high ground water table and fresh water influx during the winter will therefore always keep the salinity of pond water low. Since the salinity of the pond is already heavily influenced by the salinity in the sound (i.e. the pond receives intake water from the sound), the number of potential mariculture species suitable for pond culture at this site will be reduced considerably. A complete analysis of this site to determine salinity flux over the year and methods to manage the effects should be undertaken prior to commercial consideration. Slow acclimation will often enable the culture of some stenohaline species in waters lower in salinity than found in their natural habitat. Maintaining salinity records will enhance pond management by allowing the manager to delineate periods of greatest risk and stock species accordingly. For example, penaeid shrimp will not be able to be cultured year round unless minimum salinity levels can be maintained, but 20-25 count shrimp have been cultured in ponds from post larvae (0.6g or less) in 155 days (Tatum, in Homziak, 1983). Other species with pond culture potential at this site include hybrid bass, eels, red drum, pompano and sturgeon. Pond culture sites in the study area are shown in Figure 6.

Suitable sites for the location and construction of artificial oyster reefs is beyond the scope of this study, but conservative estimates indicate 40,000 acres of bay bottom are suitable for reef construction. Some artificial reefs, if under lease, may be suitable for additional off bottom oyster culture.

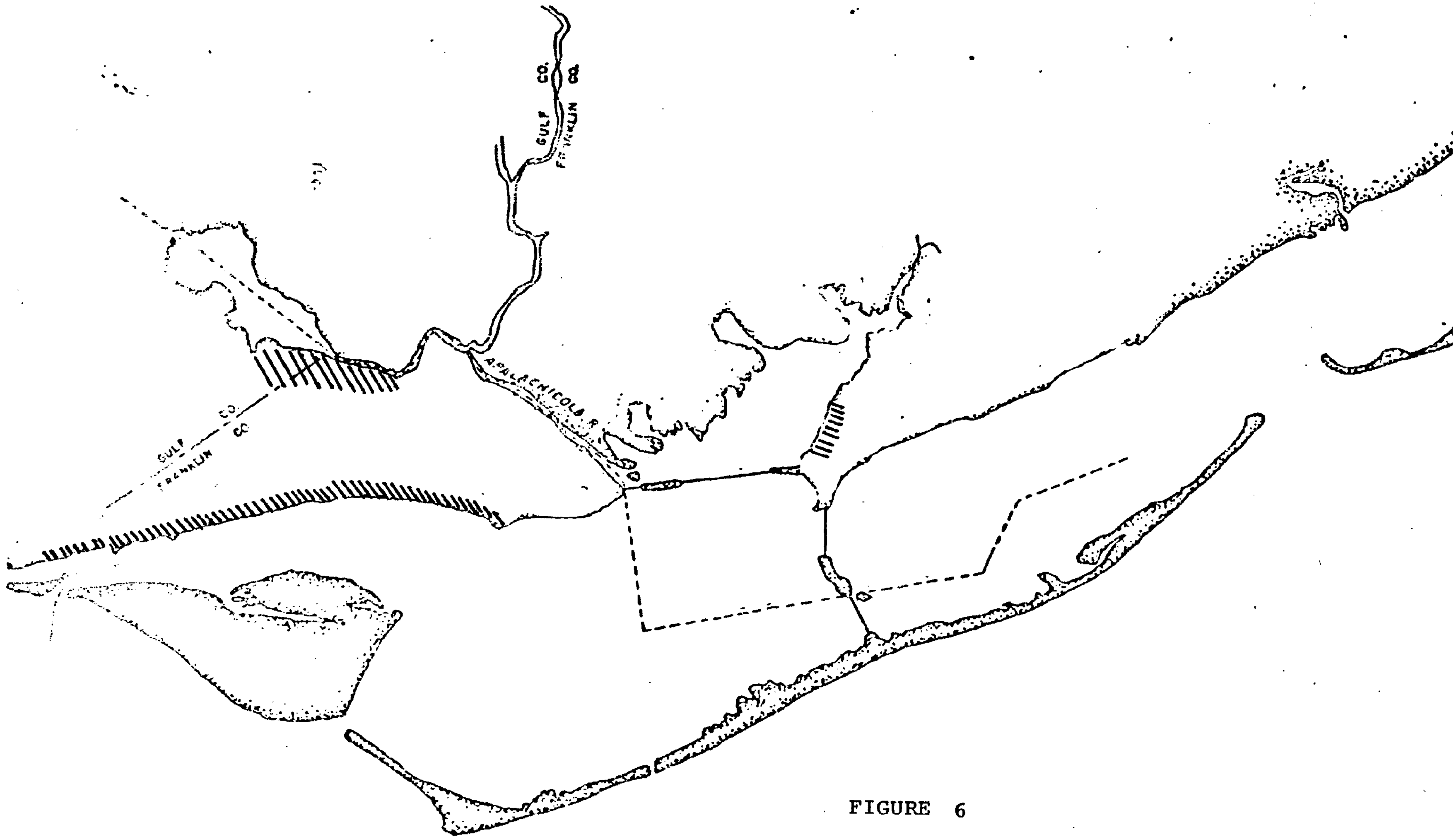

FIGURE 6

POTENTIAL POND SITES

The major factor to consider is protection from waves, tides and currents. Other considerations include navigation recreation and commercial fishing. Siting for off bottom oyster culture is nearly the same as siting for cage or net pen culture and will be discussed simultaneously.

Potential sites for off bottom oyster culture and net pen or cage culture are shown in Figures 7 and 8. Apalachicola to Two Mile Channel is a dredged waterway running primarily east-west and connecting the Intercoastal Waterway with Two Mile. A portion of the channel is sheltered by a vegetated spoil island on the south side. The north side is lined with docks, boats, houses and businesses. The area seems to be well flushed, and approximately 4 feet deep right off the spoil island with a mucky bottom. Salinity was 8 ppt, oxygen 6 mg/l and temperatrue was 30°C at 10:00 a.m. Small scale cage culture could be undertaken as a side crop for those living or parking their boats along the north shore. Potential problems include water quality degradation from human activity in the area, low tides exposing cages, rapid salinity fluxes from fresh water runoff or storm events, and theft. Th area immediately west of this area going towards Green Point is undeveloped and has potential along the north shore.

The remainder of the north side of St. Vincent Sound already has a considerable amount of oyster bars and a few oyster leases. The area appeared to be too shallow for cage culture, but is well suited to be fully developed into artificial reefs. Raft, rack or

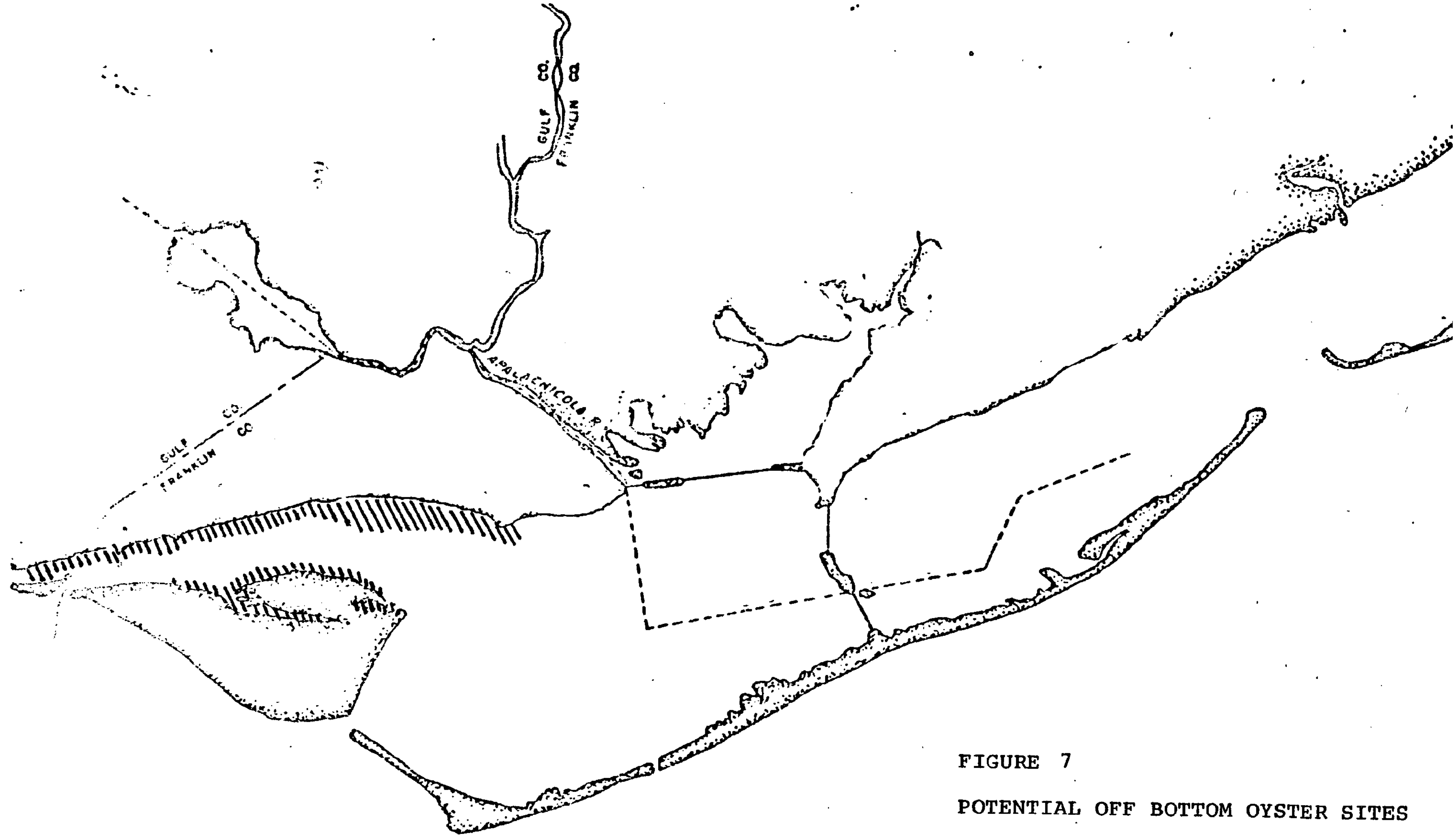

FIGURE 7

POTENTIAL OFF BOTTOM OYSTER SITES

tray culture of oysters could also be developed along this area. Salinity varied from 13 to 18 ppt.

The south side of St. Vincent Sound right off the north shores of St. Vincent Island contains many nooks and crannies sufficiently sheltered for off bottom oyster or net-pen/cage culture. Water quality appeared to be excellent with salinity of 10 ppt, DO 6.7 mg/l and temperature 30°C. Depth varied from 2 to 6 feet and bottoms were firm sand with some mud. Consideration should be given to varying tides, salinity fluxes, theft and possibly strong currents or winds at certain times of the year. Barriers for wind and currents may be necessary structures for culture operations.

Big Bayou appeared to be an excellent site as it is well protected, has good water quality, contains a seemingly inexhaustible food source for oysters, and can be well policed against theft. The salinity at the mouth was 16 ppt and 13 ppt near the end of the bayou. Cage or net pen culture could be attempted in the bayou, however off bottom oyster culture designed to fit the bayou has tremendous potential. Salinity fluxes in the bayou are unknown, silty sediments may cause some problems in rough weather, and low tides may expose a considerable amount of the area and reduce depths to dangerously low levels. While a drop in depth from tides exposing oysters for short periods of time may be beneficial, low tides coupled with freezes, such as the December '83 freeze, could result in complete mortality.

Sheepshead Bayou was not explored, however, its potential should be similar to that of Big Bayou.

Indian Lagoon is well sheltered with higher salinities (25 ppt, 33°C, DO 9 mg/l), good water quality, sandy to mud bottoms, depths of 1-6 feet, and an abundant source of food for oysters. Much of the area is leased and well suited to oyster culture. Off bottom techniques could be developed at this site as well. Marine fin fish with higher salinity requirements may be suitable for cage or net pen culture in the deeper portions of the lagoon.

Additional sites which were not examined but would have potential for cage or net pen culture are along sheltered areas on the bay side of the barrier islands. The use of Horseshoe Cove, Pilots Cove, and New Inlet off Little St. George Island should be assessed. The protection of the island as a state park eliminates development and the pollution which often results from development. Water quality should remain good, objections from riparian owners would be absent, and uses would be compatible. Areas along the eastern fringes of St. George Island such as Rattlesnake Cove, East Cove, East Slough, and Pilot Harbor may also hold potential as mariculture sites.

Dredged material containment areas (DMCA) are being used in other states for the culture of bait and food crops. The commercial operations are in the early phases of development, but their prospect for success is bright. Open water disposal is the present technique used by the Corps of Engineers when maintenance dredging channels in Apalachicola Bay. A dredged material disposal plan for the bay is currently being prepared (Brady, Leitman and Edmiston, 1984). If DMCA are an acceptable alternative, then their use for mariculture activities should receive serious consideration. The multiple use of DMCA would offer benefits of desirable location, access to good water sources, and reduced construction and maintenance costs to mariculturists. Local communities would benefit from new employment opportunities and new tax revenues. The Corps would benefit from positive publicity generated from the use of what is presently perceived as biologically and economically unproductive acreage, which might lead to the availability of more sites for use as DMCA.

The Corps has recently reviewed the concept and published a proceedings (Homziak, 1983). Redfish, shrimp, trout, bait shrimp and minnows were identified as the most promising species for culture in DMCA. Problems identified include: the characteristics of the spoil material, especially contaminents, and its suitability for culture; time compatibility of disposal with crop production; an involved, complicated, and often unclear permitting process; the absence of an economic track record for such ventures applying for commercial loans; improvement in design specifications for use of DMCA for culture; and a lack of experience in managing such areas with such dual purposes. Sites in Apalachicola Bay suitable for DMCA aquaculture should be limited to those areas where the Corps have previously disposed of spoil resulting in a build up of sediment which is often exposed at low tides. Such sites are near Two Mile, The Two Mile Channel and the Intercoastal Waterway and are shown in Figure 9.

A final area for site assessment lies along the Intercoastal Waterway traveling through the Jackson River and Lake Wimico. Cage/net pen culture and upland pond culture of freshwater fishes might be feasible. The water is primarily fresh and this would eliminate many euryhaline species. Water quality is good, but accessibility is poor. However, existing technology for freshwater aquaculture is readily available. Concerns would primarily be with interference with navigation, consumptive use of channel waters and environmental concerns reflected in the permitting process as much of the area seems to be wetlands. No site visits were made in this area and as a result no sites were identified.

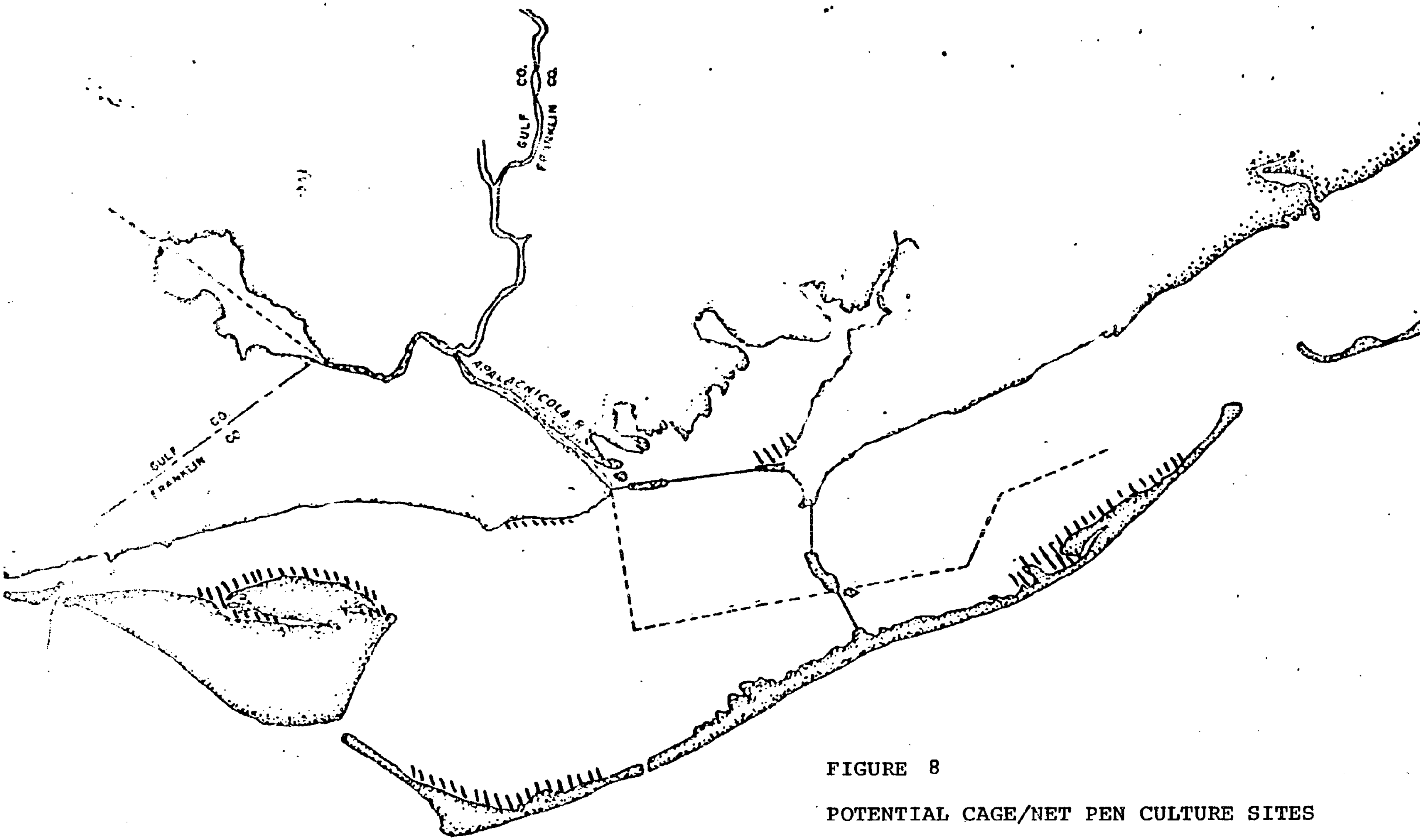

FIGURE 8

POTENTIAL CAGE/NET PEN CULTURE SITES

IX. THE REGULATORY PROCESS

Farming the sea means farming the seas coastal margins, bays and estuaries as this is where nearly 90% of the worlds food fish spawn, mature and get captured. The conditions which make mariculture attractive to a given coastal area are the same conditions which make the area attractive for people to live and play. Conflicts among competing users are a significant threat to the development of aquaculture along the coastal zone. The most significant public issue is whether or not an individual should be allowed to privately own (lease) and make a profit from a commonly held natural resource such as the sea (Bowden 1981). This will involve some basic changes in the legal system and established bureaucratic thinking in order to develop this wholly new economic activity.

Our forefathers farmed the land long before they began to regulate themselves and laws governing farming evolved along with farming technology. Laws governing the hunting and gathering techniques of commercial fishermen and recreational anglers evolved long before mariculture was given serious consideration. As a result mariculture is often governed by commercial and/or recreational fishing laws. Mariculture is a farming technique and not a fishing technique and the issue becomes whether or not our regulatory system can accommodate a new use of our coastal resources.

In 1978, the National Research Council found that the constraints on the orderly development of aquaculture tend to be political and administrative rather than scientific and technological. This statement was reaffirmed in the 1983 National Aquaculture Development Plan (NADP). There are few laws designed to promote and protect aquaculture. That is, aquaculture does not fit into existing agricultural programs and as a result is regulated at each level of government by a number of agencies each who have their own range and scope of different state and federal programs (Wypyszinski 1983). This absence of direction and coordination has resulted in fragmented and overlapping regulatory jurisdiction adversely impacting the fish farming industry. The number of agencies participating in the permitting process of an individual aquaculture facility is often large while regulations are highly complicated and often require technical experitse to understand. Most laws do not address the needs of the industry and in fact, programs or policies often conflict with one another. The problem stems from broad definitions and policies defined in law, taken by regulatory agencies, who propose and adopt detailed regulations which try to cover every possible activity that might come under that broad policy definition. The National Aquaculture Act of 1980 (PL 96-362) sets up a framework for federal policy and direction to identify problems and recommend solutions, collect and disseminate information, and coordinate federal activities and programs.

A fundamental problem with regulatory agencies is that the basic information on aquaculture as an industry and for issues and policy considerations hindering its development, are not readily available (Conte 1982). Thus, there is inadequate information on what regulations apply to a specific aquaculture situation leaving regulators uncertain whether or not a permit is needed and whether or not specific rules are applicable. The end result is many well intended laws developed to meet public needs at local, state and federal levels which were written without considering aquaculture. Aquaculture impacts our regulatory process in a number of areas including: land and zoning regulations; water and water quality regulations; environmental, including dredge and fill, placement of structures in Navigable waters, and facility discharges (NPDES); fish and fisheries management; facility and hatchery management; FDA drug registration and shellfish sanitation; coastal protection; wildlife protection; introduction of non-native species; transport of live animals; and the normal business functions such as taxes, workmans compensation, and safe work places.

A need exists to identify state rules and regulations which could potentially affect the initiation and operation of an aquaculture enterprise and to define the practical effects of these laws and regulations on specific culture operations. The end result will hopefully be to remove regulatory impediments to aquaculture by eliminating regulations not intended for aquaculture or by streamlining the regulatory process as it applies to aquaculture. This is underway at the federal level as mandated by the National Aquaculture Act and will be reviewed on the state level during the coming year as prescribed by The

Florida Aquaculture Policy Act of 1984. Bowden (1981) has proposed a four point solution: A central permit register describing each permit required at all government levels; creation of a lead agency with direct interest in aquaculture; formation of a joint hearing procedure where all problems connected with a single project can be sorted out; and appointment of an administrative advisor to explain and assist in the bureaucratic process and reduce the procedural trauma experienced along the way. Presently, culturists feel the permit process is lengthy and uncertain. This diverts a significant amount of entrepreneurial energy away from the start up phase of the culture operation and into the bureaucratic process resulting in undue and increased risks.

A. COASTAL ZONE MANAGEMENT

Mariculture is a resource dependent activity of the coastal zone. It is coastal dependent and as such should have priority over other developments on or near the shoreline (Conte 1982). These statements sum up the sentiments of all culturists in that mariculture should be a designated use of the coastal zone with areas set aside for culture activities as determined through the planning process. The Coastal Zone Management (CZM) Act of 1972 (PL 92-583) is the logical place to include aquaculture in the planning process. The Act creates a process for federal and state cooperation in coastal management and fund the preparation and administration of plans. The federal guidelines were adhered to by passage of the Florida Coastal Management Act (Chapter 380 FS) which instead of a plan, produced an environmental impact statement entitled the Florida Coastal Management Program (FCMP). Water dependent uses, such as aquaculture, fit into the CZM scope. However, the FCMP only briefly addresses aquaculture leases under: Statutory Authorities and Policies: Ownership and Management of Public Lands. Aquaculture site criteria, policies and designated areas could have been fully addressed under the Commercial and Recreational Fisheries Section. The FCMP does recommend the program address ways to maintain, promote and enhance commercial and recreational fishing industries in a fashion that is consistent with the long term productivity of our living marine resources. This recommendation seems to leave the door open to incorporate aquaculture into future program revisions or implement it at the local planning level. However, the flexibility of the FCMP to incorporate new coastal uses which evolve over time is uncertain.

The Comprehensive Plan Franklin County (Apalachee Regional Planning Council) was produced in response to the local Government Comprehensive Planning Act of 1975 (Chapter 163 F.S.). The plan does not adequately consider all uses of the available water resources and doesn't discuss aquaculture, yet the top two key issues for growth management are maintenance of the resource based seafood economy and maintenance of water quality in the bay. The general policy is to protect, maintain and foster the growth of the seafood industry for generations to come by minimizing or preventing pollution sources from entering the bay or by placing special requirements on construction along the coastal zone to protect water quality. General growth objectives and policies Objective XXIII suggests limiting development in areas vital to the functioning of marine ecosystems or vital to the sustained harvesting of shellfish, while Objective XXIV states that ANES should identify past damage to the ecosystem and appropriate programs for restoration so that the county could then formulate methods for management of the watershed. The plan does talk about zoning and land use to provide for activities related to commercial fishing expansion and specifically mentions marine culture shore facilities including seed oyster rearing, oyster fattening and blue crab culture (E. Commerce. 11.d(1)(d)). However, none of these policies, objectives or statements specifically discuss or recommend methods to enhance or manage the resource to incresae and maintain fisheries production. Encouraging aquaculture development is not addressed.

There seems to be a contradiction in that the plan wants to preserve the estuary as it is through preservation techniques such as aquatic preserves, sanctuaries, state parks, EEL, OFW, etc, which will certainly help to maintain good estuarine water quality, but will do nothing towards protecting the resource from overfishing or natural biological processes. The resource needs controlled management with some environmental manipulation which could be addressed with mariculture techniques. The Franklin County Plan objectives and policies discussed above certainly seem to leave the door open for inclusion of a mariculture element or development of a separate comprehensive fisheries plan as recommended in the oyster species plan assessment.

B. ENVIRONMENTAL REGULATIONS

Activities impacting environmental quality in Florida are regulated by the Department of Environmental Regulation (DER). DER attempts to evaluate potential pollution sources through construction permits prior to the start up of an operation. DER examines the permit application to see if the proposed source utilizes appropriate technology to remove pollutants from the discharge and for impact of the discharge on the environment. This is permitted through the National Pollution Discharge Elimination System (NPDES). The Environmental Protection Agency (EPA) is the federal administrator of NPDES and has developed criteria for permit application evaluations based on the impact of discharges on human and animal health and marine life (40 C.F.R. 227-4). Generally this means a potential aquaculture discharge cannot negatively impact the marine ecosystem nor human health. Discharges from intensive aquatic animal facilities are covered by general NPDES permits and are divided into cold and warm water facilities with maximums defined by 40 C.F.R. 122.43. EPA exempts warm water fish culture facilities if discharge occurs less than 30 days per year or only occurs during periods of excess runoff or if the facility produces less than 100,000 lbs. of round weight product. DER provides state certification of a NPDES permit to insure compliance with state water quality standards. DER usually acts within ninety days of receiving the permit application from EPA. NPDES permits may be required for ponds, hatcheries, closed intensive systems, and possibly net-pen culture. None are required for artificial oyster reefs.

Dredge and fill permits are another regulatory function of DER and are required for most activities in wetland areas and along the coastal zone. A dredge and fill permit may be required for ponds, unless the site is in an upland location out of DER jurisdiction. A permit application must also be filed for structures placed in navigable waters or waters of the state which would include structures associated with net-pen culture and off-bottom shellfish culture. Assistance in recognzing the need for a permit may be obtained from any DER field office. Types of activities, agency contacts, requirements and a description of the permitting process are provided in the DER publication "Regulatory and Review Procedures for Land Development".

Permits for dredge, fill and structures are jointly administered by DER, DNR and the Corps of Engineers (COE) using a single application. Other agencies which may become involved on a review and comment basis include the Coast Guard, Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), Game and Fish Commission, Department of Community Affairs, Water Management District, and local government. Each of these agencies varies in their jurisdictional roles and level of involvement depending on the scope and magnitude of the individual application. For example, FWS is concerned about the effects of a proposed operation on habitat and native stocks as well as the importation and interstate shipment of plants and animals (Lacey Act). While FWS is highly supportive of freshwater aquaculture, they are adamantly opposed to most mariculture activities. The COE is very tough on dredging and filling activities, but very helpful in acquiring permits to use dredge material containment sites for mariculture. Statutes which may apply to such activities include:

Beach and Shore Preservation Act, Chapter 161, F.S.
State Land Trust Fund, Chapter 253, F.S.
State Parks and Preserves, Chapter 258, F.S.
Florida Air and Water Pollution Control Act, Chapter 403, F.S.

Chapter 253 is the only statute which specifically addresses aquaculture and aquaculture leases. The remaining statutes as well as others pertaining to water and water use are silent about aquaculture, which can be viewed as a constraint to aquaculture development.

Protecting and conserving the quality of water in the state is a concept shared by both regulators and fish culturists. Clean water is essential to an aquaculture operation in order to produce a healthy good tasting product. An owner or operator of a facility where animals are confined for feeding or one which may have a discharge of waste must apply for a permit. A hatchery or net pen system may or may not fit this classification. However, laws such as NPDES and the Clean Water Act are restrictive in that they fail to distinguish between biodegradable wastes produced by fish operations and chemical wastes produced by industry (Wypyszinski 1983). The concern over discharges from a culture system, especially a net pen operation, are overstated since discharged effluent is the natural metabolic waste product of marine animals and a natural component of the marine environment. They are comparable to discharges of oyster reefs and fish populations and when properly disposed under permit guidelines have negligible impact on an ocean or bay system (Conte 1982). Wastes from a net pen system originate from uneaten feed or fish feces. While these systems tend to have an effect on the bottom directly beneath the pens, no effects have been documented to adjacent surrounding bottom. In fact, a net pen system often attracts other fish and crabs which consume uneaten feed and metabolic wastes and can be harvested for extra profits. These wastes may also be assimilated by oysters.

Metabolic wastes eminating from a net pen culture are usually subject to flushing by tides, winds and currents. Assessing their impact on an estuary such as Apalachicola Bay would be a difficult undertaking. Livingston (1983) reports there are 34,200 tons of carbon, 668 tons of nitrogen, 197 tons of phosphorus, and 214,000 tons of organic matter which enter Apalachicola Bay each year. Nutrients are highest in winter when river flow is highest which is also the best oystering season. The oysters absorb more water and expand during these periods of high freshwater inflow indicating uptake of some of the organic matter. There are many factors including time of year, river discharge, primary productivity rates, temperature, flushing rates, and other biological productivity which all contribute to the nutrient concentrations in the bay. It is an extremely complex system and not completely understood (Livingston 1983). Nutrients may go into the sediments or into phytoplankton production which is cyclic and dependent upon a number of factors too. The connection between upland nutrient sources (forest litter, etc.) and recycling in the estuary is unknown. Therefore, concentrations of nutrients and metabolic wastes originating from a net pen operation or artificial reef would appear to be insignificant when compared to the overall magnitude of nutrient and organic release from the ACF system and complexity of nutrient cycling in the bay. Research to determine the amounts of uneaten feed and metabolic waste products from an aquaculture operation, their dispersal, ultimate fate, and positive or negative impact on the estuarine system might answer many questions. This research should be a function of the federal government.

C. BOTTOM LEASES

Mariculture requires access to lands and waters adapted for its purposes. The Florida Cabinet sitting as the Board of Trustees of the Internal Improvement Trust Fund administers all state owned lands and shall be responsible for the creation of an overall and comprehensive plan of development concerning acquisition, management and disposition of state-owned lands so as to insure maximum benefit and use (Chapter 253.03 (7) F.S.). Responsibility for the leasing of state bottoms for oysters and shellfish has been delegated by the Trustees to DNR and specifically defined in Chapter 370.16 F.S.

The statute requires minimum quantities of cultch (656 bu/acre) and annual cultivitation guidelines until the entire lease is under cultivation. The law defines transfer, revocation and forfeiture of the lease. Transfer of a lease is barred by sale or barter until the lease has been in existence for a minimum of two years and has been cultivated according to the standards outlined in the lease. Rental charges are $5/acre for the first ten years and increase a minimum of $1/acre thereafter. The DNR is presently re-evaluating lease fees. The rental change may be based on the probable rates of productivity, marketability, and value of the product produced by the operation. Florida law gives the cultivator exclusive property rights to the shellfish planted, but poorly defines the rights of the public (Kaplan, 1984). Tresspassing and the taking of leased oysters is a first degree misdemeanor. The statute also singles out Franklin County as being the only county in the state prohibitng future leases. This section 370.16(9) would have to be amended prior to the initiation of a leasing program in Franklin County.

A draft DNR manual for shellfish leases is included in the Appendix which clearly explains the procedures required by the applicant and agency response. There are presently 191 active shellfish leases in Florida ranging from less than one acre to 177 acres. However, the DNR believes that many leases are not actively being farmed and checking each lease for compliance is nearly impossible to enforce. The DNR presently has a moratorium on granting new leases. The seemingly restricted use of submerged lands coupled with high adjoining land values has restricted extensive mariculture systems. This may force the ndustry to move towards more intensive systems which require higher energy costs, higher densities and greater environmental manipulation. If these systems are designed to have minimal environmental impact, then this use of a smaller space with maximum environmental control should result in fewer coastal use conflicts.

D. <u>WATER COLUMN LEASES</u>

In 1969, Florida passed a very progressive aquaculture law allowing the lease of both the water column and the submerged land below it (Chapter 253.67-253.76 FS and 16Q-17 FAC). A review procedure for obtaining a water column lease is given in the Appendix. The legislation was intended to respond to the needs of the mariculturist by broadly drafting legislation flexible enough to accommodate new mariculture technologies. The Florida law was a decision to encourage aquacultural enterprises by granting exclusive use of the water column to the mariculturist since existing law was unable to accommodate this need. Legislation is required not only to protect the activities of the mariculturist, but also to clarify the rights and responsibilities of conflicting interests in the coastal waters. Ambiguities from poor drafting and failure to respond to all issues or innovation have resulted in an awkward legal process for the mariculturist. Since enactment, not much has been accomplished with regards to aquaculture ventures utilizing the water column. While some of this lack of interest can be placed on the private sector, inadequate techniques for commercialization, and competing land values, problems with the law and administrating agencies in achieving this specific objective have tended to discourage full implementation of the statute.

DNR is given administrative discretion in determining what areas may be leased. The law (253.75(2)(c)) requires DNR to designate areas for non-aquaculture use, but remains silent on designating potential aquaculture sites. DNR must make a lease assessment and a recommendation to the Trustees prior to the granting of a lease. The assessment must include riparian rights, navigation, commercial and sport fishing, and the conservation of fish or other wildlife or other natural resources, including beaches and shores (253.75(1)). The Trustees have the final authority in determining conflicting use priorities and are not required to follow the DNR recommendation. However, local politics may prevent the siting of an aquaculture enterprise by a simple majority veto by county commissioners (253.68).

The size of the lease is flexible; however, the law tends to encourage a smaller lease for experimental purposes prior to granting large tracts for commercial purposes (Owen, 1978). In fact, DNR must determine in advance whether or not the lessee is competent to carry out the terms of the lease (253.71(3)). A reasonable area of adjacent bottom land may be held in reserve for the time when a holder of an experimental lease will begin operation under a commercial lease. Leases may be for a maximum of 10 years at which time public notice for renewal is given. The law is ambiguous as to whether or not priority must be given to the present lessee upon releasing the area. This may be viewed as a deterent to aquaculture development.

Riparian owners must be notified of the proposed lease and must file written approval or given the opportunity to present objections prior to the issuance of a lease. Riparian owners therefore seem to have a preference right or veto power to the leasing of submerged lands, but there is no mention in the statutes saying if preference rights can be overcome by a higher bid (Kaplan, 1984). Determination of rents is left to DNR. In the past DNR has charged a basic rent plus royalties after the operation is established. This procedure has been criticized in an independent study performed on a penaeid shrimp operation (Snedecker, 1975). A performance bond is required by the lessee to insure that cultivation will be actively pursued (253.71(4)). Insurance companies presently charge a premium plus full cash collateral, as the way Chapter 253 is presently written, the insurance company and not the lessee is guaranteeing the performance of the aquaculture lease. Finally, in order to comply with the states audit procedure, two sets of books must be kept adding to the headaches of the mariculturist.

Procedural requirements to reconcile conflicting interests are necessary to obtain a lease, but have the effect of creating a paperwork burden on the applicant and impede the application of new technology (Owen, 1978). The applicant must demonstrate competency, gain local acceptance, post a bond, notify riparian owners, and then engage in regulatory involvement with a number of federal and state agencies before the lease can be implemented. A coordinating body or joint hearing process could keep this burden to a minimum.

The statute (253.72(3)) allows exclusive use of the area only to the extent necessary to permit effective development of the species being cultivated by the lessee. The public is then provided reasonable ingress and egress to and from the clearly marked leased area for boating, swimming and fishing. DNR requires the lessee to survey the quantity of public marine resources which will be lost and to perform rehabilitation, stocking or other remedial projects as would tend to improve the marine productivity diminished by the lease (Owen, 1978). This may place a great burden on the potential mariculturist. Marine species and ecology are further protected by Chapter 370, F.S. However, Florida law is not clear on distinguishing a natural species from one artificially cultivated.

If water quality violations occur as provided in Chapter 403, F.S., the lease may be cancelled. This increases risk and places the day to day survival of a venture at the mercy of a regulatory agency. The lease may also be revoked if the activities for which lease was granted are not substantially performed or for failure to pay rent. Finally, any person poaching on the lease shall be guilty of trespass and punished for up to 60 days in prison or by fine not exceeding $50 or both (253.72(2)). A DNR flow chart of aquaculture lease procedures is shown in Figure 10.

In summary, the Florida law attempts to respond to the needs of mariculturists by granting exclusive use of the water column and at the same time attempts to respond to compatible uses and conflict resolution through its application and revocation procedures. However, as the above discussion reveals, many legal and procedural barriers stand in the way of obtaining a lease. In Franklin County, the initial and major obstacle to obtaining a lease is gaining local acceptance.

E. SHELLFISH SANITATION

The Shellfish Sanitation Program has been administered by DNR since 1975. DNR maintains a shellfish laboratory in Apalachicola which monitors oysters and water for potential health problems. Franklin County has the greatest amount of water quality monitoring in the state. DNR has recently published a table using river stage and cumulative three day rainfall to predict bay closings. Authority is granted under Chapter 16B-28 FAC. DNR also classifies and approves waters for shellfish harvesting based upon those factors influencing the sanitary quality of a growing

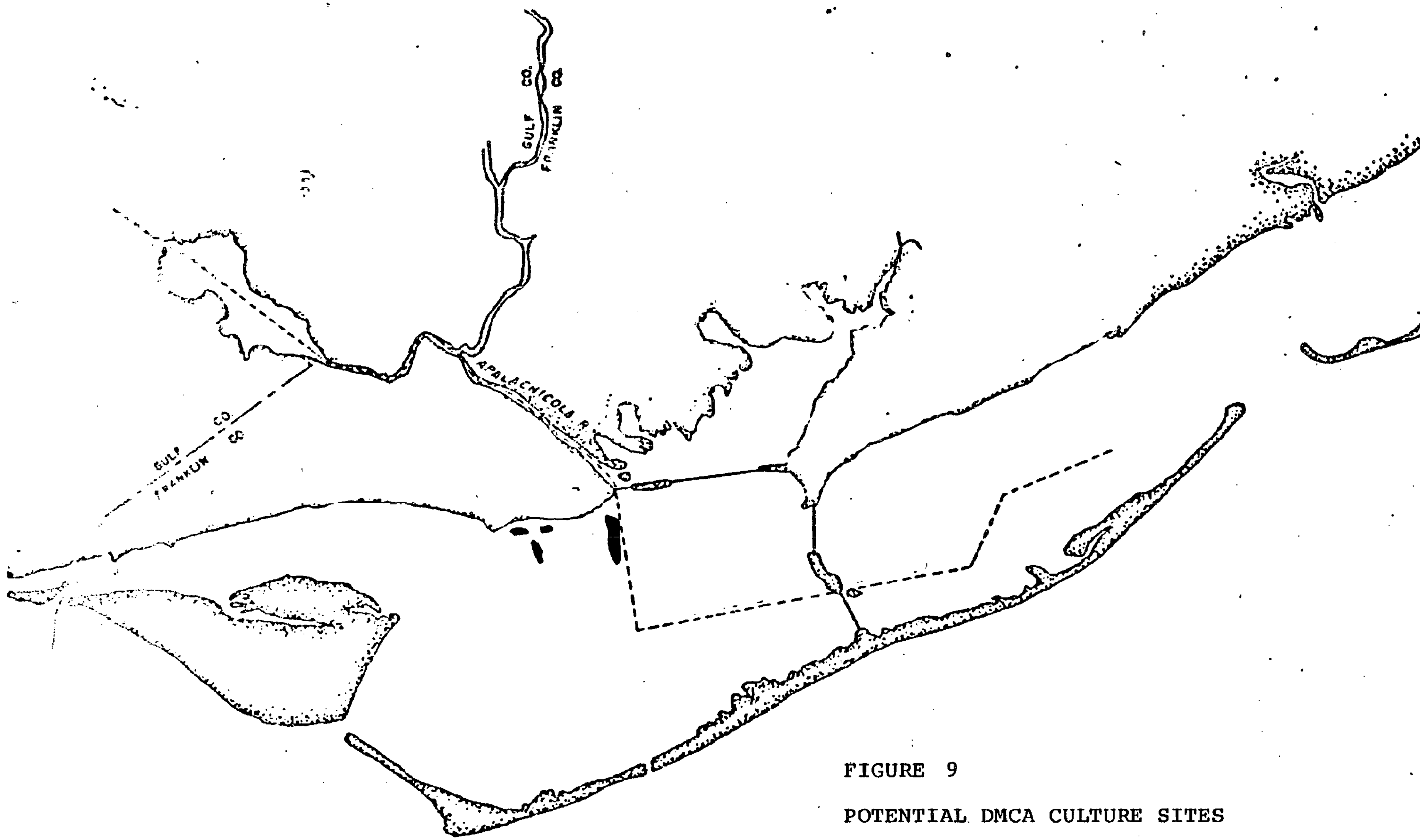

FIGURE 9

POTENTIAL DMCA CULTURE SITES

area. The DNR program has gone on record as stating "shellfish culture and harvesting represents a beneficial use of water in estuaries" (Futch and Schneider, 1984). Permits required by this program are limited to an oyster harvesting permit and permits relating to oyster houses and processing.

The Interstate Shellfish Sanitation Conference (ISSC) is a fairly recent organization composed of state agencies, FDA, NMFS, and the shellfish industry. Its purpose is to provide a formal structure for state regulatory authorities to establish uniform guidelines and procedures for controlling shellfish sanitation. This voluntary organization will be formulating nationwide guidelines. Two meetings have been held, the most recent in August, 1984, in Orlando. The effects and impacts of this program are presently unknown, however, industry has-been favorable to the initial results.

F. CONCLUSIONS AND RECOMMENDATIONS

Mariculture is a coastal dependent use compatible with a number of existing coastal land uses. Regulatory agencies should work with the industry to encourage the location and development of mariculture facilities which fit into the local planning philosophy. Regulatory agencies should be flexible in permitting individual aquaculture ventures and assist applicants in obtaining the necessary permits for an acceptable project. Aquaculture is an agricultural enterprise which can add to existing food supplies, enhance fisheries and contribute to the stability of a coastal area's economy. Specific recommendations are:

(1) The Florida Aquaculture Policy Act (Chapter 84-90, F.S.) should be supported to encourage the orderly development of mariculture activities in the coastal zone.

(2) A complete legal review of all pertinent laws should be carefully undertaken to resolve problems due to cross referencing, jurisdictional overlap and the use of ambiguous terminology in order to clearly define aquaculture in statute, reduce uncertainty, and clarify authority.

(3) Aquaculture should be designated as an appropriate and priority use of the coastal zone in coastal management programs.

(4) Local governments should define aquaculture as agriculture for the purpose of zoning codes.

(5) A series of hypothetical culture systems and lease situations should be run through the permitting process to assist in finding problems with the process, assess the time and cost requirements involved in obtaining a lease, and measure the impact on developing such a new industry.

X. AQUATIC USER GROUPS AND MARICULTURE

Coastal waters in Florida can presently be considered an underused resource especially regarding mariculture. Development of an aquaculture industry will only heighten conflicts among present users of the coast. Established users usually resist a new use such as mariculture due to the belief of competition for access to the resource. No one person or industry has the right to exclusive use, but rather must conduct themselves in a manner consistent with rights of others to use the same area. Administrative agencies must be able to reconcile conflicting interests equitably among users. Resolution of conflicts, especially those new ones created by mariculture development, will depend upon how badly we come to need the things mariculture can provide.

Bowden (1981) has thoroughly reviewed the issue of creating private property rights in the sea and declared it the single most important public policy question raised by marine aquaculture. He concluded that the public interest could be well served by creating limited or common property rights in the use of coastal waters for aquaculture. Common property rights can be defined as rights of use, disposition and capital gain in a natural resource held by a class of co-equal users whose membership and use rights can be expanded only by government (Bowden pg. 191). Many of the barriers identified to the successful development of an aquaculture industry can be removed by addressing the question of property rights. Defining property rights along with sound planning procedures should clarify the competition among traditional attitudes for access to the resource and reconcile conflicting views. The traditional or established users include commercial fishing, recreation, property, ownership, aquatic habitat preservation, and navigation.

Commercial fishing in Apalachicola Bay includes tonging for oysters on public bars, shrimping in all parts of the bay except East Bay, and seining of fishes such as red drum, mullet and trout. Although oystering only occupies a small percentage of space in the bay, the potential to create public bars on a much greater area of the bay leads many oystermen to believe that aquaculture would be in direct competition with their right of access to public submerged lands. The strongly independent oystermen believe all of the sea to be a common resource and fears that aquaculture would lead to monopolies and big business control of the bay bottoms. They also fear that this would then lead to price and market control. Not all oystermen are opposed to aquaculture. In fact, nearly all of them support public artificial reef buidling if constructed properly. Many do not oppose non-oyster aquaculture and many more realize the severity of the present problems confronting the oyster industry.

Aquaculture would directly compete with bay shrimping and some fish seining for space in this shallow bay. A good allocation system could easily resolve this problem. The advantages of aquaculture cannot be ignored. Creation of artificial oyster reefs whether public or on leases, would enhance the overall fisheries resources of the bay. Aquaculture does not necessarily eliminate all other uses. Aquaculture can contribute when fisheries are in short supply or unavailable during parts of the year, it may help to stabilize prices, and it offers new opportunities for those who can no longer make ends meet in commercial fishing.

Although recreational fishing is considered good in Apalachicola Bay, speckled trout and redfish, the top two sport species, are declining in population. Fishing is good over the grassflats in the bay, from piers and causeways, passes, and in the tidal creeks and river mouths where bass are also sought. Fishing is considered good in all but the coldest months of the year. Live and dead shrimp are the best bait. Some anglers believe the bay is on the decline while others observe there is a continual increase in the number of sports fishermen.

Competition between aquaculture and sports fishing, or recreation in general, is not considered to be a serious problem. The major issue is equal access. Presently, the intent of Florida law is to allow coexistence as long as the recreational angler is not disturbing the culture operation. Aquaculture facilities often act to attract fish which recreational anglers can catch without disturbing the cultured organisms. Aquaculture may also relieve pressure on wild fisheries and provide more fish through stock enhancement programs. Recreational oyster harvesting is not considered a threat to commercial oystering. And aquaculture is usually carried out in waters not used for boating and swimming.

The major conflict is between commercial and recreational fishing. Recreational anglers complain that commercial fishing methods have become too efficient and have the ability to completely deplete natural stocks. This sophistication results in the catching of more fish each year and is presently worth $288 million per year (Bell, 1984). Commercial fishermen complain the recreational anglers are catching too many fish, are driving down the price by selling their catch for less than market value, and are threatening their right to earn a living. However, Bell (1984) found the worth of Florida's marine resources as sports fishing value to be a $27 billion assets with $5 billion generated directly and indirectly by business, $1.4 billion in wages paid to 124,000 jobs, and paying $150 million in taxes. Overall, the amount recreational fishermen spend on gas, oil, food, beverages, motels, slip fees, rentals and bait is more than five times the value of the annual commercial catch. Bell noted the success rate of anglers is dropping which could have severe economic consequences for the state. The portion of these figures which relate to Apalachicola Bay are unknown; however, recreation is clearly the most important economic use of the resource. Aquaculture could, therefore, never hope to directly compete economically with recreational fishing nor should aquaculture get caught in the battle between recreational and commercial fishing. However, as previously stated, aquaculture could both help supply the presently unfulfilled demand for seafood and enhance natural stocks thereby relieving some of the pressure off the resource.

Extensive development on St. George Island is not only a threat to aquaculture development, but to the entire fisheries ecology of the bay. Developers must realize there can be no compromise if the bay is going to be saved and they must be willing to pay the extra costs associated with development which will protect the bay. Aquaculture, in turn, must then be developed so as to be aesthetically pleasing to property owners. Proper design to blend into the environment can help to eliminate competition between these two users.

The COE and Coast Guard would never site an aquaculture facility if it would interfere in any way with commercial navigation. Boaters or commercial fishermen, such as bay shrimpers, may have a limited conflict with aquaculture.

In summary, the resolving of conflicts among various user groups can be accomplished through sound comprehensive planning where all uses are allocated space, rights and access in an equitable manner. Aquaculture is compatible with many of the other uses. In the end, the solutions must be both socially and economically acceptable.

XI. MARKETING, ECONOMICS AND FINANCING OF AQUACULTURE PROJECTS

A thorough analysis of the economics of production, financing the operation, and marketing the final product must be undertaken for each individual aquaculture venture and the species it cultures. This type of detailed analysis is beyond the scope of this study. This section describes some of the basic needs and requirements of developing a business plan, locating the required capital, and developing markets as they might relate to a mariculture operation in Apalachicola Bay.

Business Plans

Lenders and investors need to know specific details of a proposed aquaculture venture which is usually provided in the form of a business plan. The plan should take a realistic view of the viability of the entire proposed operation identifying strengths and weaknesses, anticipating problems, and mapping out methodology to achieve the goals of the business. A business plan should eventually be the blueprint for operating the business. The three essentials for a plan are what the business is, how it will work, and why will it work.

Contents of a business plan vary with the type of proposed venture. An outline of essential elements to consider in a possible aquaculture business plan has been taken from Rhodes (1984) and shown in Table 6. Financial projections, especially cash flow are of great importance. Timing of production with cash flow on a monthly basis for a minimum of three years will be both an effective planning tool for the business as well as allow the lender to assess the proposed operation, especially as it relates to repayment of loans or potential earnings. The experience and management capabilities of the principal(s) are also of great interest to lenders. A marketing strategy is a key component of a business plan which sets a profitable pricing policy, targets markets, details product promotion, and assesses current and future competition. Finally, a business plan needs a cover letter which succinctly states the goals of the business, the amount of capital to be borrowed, and terms desired.

TABLE 6
AQUACULTURE BUSINESS PLAN OUTLINE

I. Summary
    A. Name and location
        1. Name and location
        2. Species
        3. Porduction facility and site
        4. Target market(s) and competition
        5. Management expertise
    B. Goals of business
    C. Summary of financial needs and use of funds
    D. Earning projections
    E. Repayment capabilities and/or potential return to investors

II. Market Description
    A. Overview of different market segments for species
    B. Target Market(s) and trends
    C. Competition: Current and future

III. Aquaculture Product(s) and Technology
    A. Species descriptions
    B. Facility and site description
    C. Proprietary position: Ownership of production site, patents, pending, other techniques and legal considerations
    D. Permitting requirements and other regulatory considerations

IV. Aquaculture Production Technology
    A. Brood and/or seed stocks: Sources and quality
    B. Water quality controls
    C. Production techniques

V. Marketing Strategy
    A. Overview
    B. Pricing policy and product form
    C. Product promotion
    D. Marketing logistics

VI. Management Plan
    A. Legal form of organization
    B. Owners and/or Board of Directors
    C. Responsibilities by key personnel
    D. Resumes of key personnel
    E. Staffing and hiring plans
    F. Facility construction/improvement plan
    G. Species production schedule (first year by quarters; remaining years annually)

VII. Financial Data
    A. Current and past financial statements (if applicable)
    B. Three to five year financial projections (first year by quarters; remaining years annually)
        1. Capital expenditure projection
        2. Income (profit and loss projection)

3. Balance sheets
4. Cash flow projections

C. Description of projects, including assumptions
D. Key business ratios
E. Description of use and effect of new funds
F. Explanation of repayment capabilities/potential return to investors

SOURCE: Primer on Aquaculture Finances, Planning For Success, Part I. Raymond J. Rhodes Aquaculture Magazine Vol-10, No. 1 Dec. 1983.

Sources of Capital

Securing the necessary capital to develop and operate an aquaculture venture may be obtained from private, public and commercial sources. The sources differ in the amount of risk they are willing to take and the amount of interest they charge which often depends on the type of operation and the legal form of the company. Personal savings and loans from relatives are private sources and are good places to look for capital when developing the early stages of a business. Venture capitalists are another source of private capital. They must be found by the operator and usually require a rapid and high rate of return on their investment.

The Farmers Home Administration (FHA) offers direct or guaranteed loans for feeding, tending, harvesting and other activities necessary to raise and market aquatic products (NADP, 1983). Emergency loans are also available from FHA. FHA primarily makes loans for established operations and species with a strong track record and usually for freshwater operations. The Federal Crop Insurance Corporation has established an all risk crop insurance program for fish farmers.

The Farm Credit Administration (FCA) administers several lending institutions such as Production Credit Associations (PCA), Federal Land Banks (FLB), and Federal Intermediate Credit Banks (FICA). These institutions can make loans on commercial terms which support the production or harvesting of species under controlled conditions, primarily the fisheries industry (NADP, 1983). Mariculture operations are included. PCA's usually give intermediate term loans less than 11 years for purchase of capital items, while FLB's are the major source of long term loans exceeding 10 years. FCA institutions require collateral, a business plan with financial projections, and often require the borrower to buy stock in the institution. However, these institutions are sensitive to the needs of the people they serve and members (borrowers) serve on the board of directors.

The Small Business Administration (SBA) makes guaranteed, immediate participation, and direct loans to aquaculture operators and provides disaster loans in authorized areas. SBA loans may be used for purchase and improvement of land or buildings, construction, machinery and equipment, operating expenses, and refinancing of debts (NADP, 1983). SBA provides business assistance to a new business and disseminates information on other sources of financial help. SBA also coordinates the Small Business Innovation Research Program which is designed to give small businesses approximately $500 million of all research and development monies contracted out each year by federal agencies. The awards may require three successive phases of research, demonstration and commerial development and are primarily geared to innovative or hi-technology needs of the agency's choosing. Several aquaculture firms have received SBIR monies.

Commercial banks are the last source of capital and they make the greatest number and variety of loans. Banks are conservative lenders and generally do not make bad loans. Banks evaluate the applicants collateral, their ability to repay with business profits, management capabilities, and the applicant's character or personal record (Rhodes, 1984). Banks in Franklin County have a vested interest in the community and may be the best source of financing local aquaculture ventures.

Aquaculture can be a risky business. It often requires large amounts of energy, materials and capital. Operating costs can be high especially if feed and pumped water have to be supplied. Aquaculture is presently labor intensive; intensive crops are susceptible to disease, and a period of time must pass before the product is harvested and cash flows into the operation. Security must be provided, especially for an operation such as a shellfish lease where theft can put an operator out of business. Insurance underwriters lack the expertise to assess risks and have too few aquaculture ventures in which to spread the cost of the risks. Regulations are both costly and time consuming. Each of these factors create an added risk to an aquaculture operation, making the securing of a loan difficult.

Marketing

Fish and shell fish are in the future of the American diet. Per capita consumption of seafood products will continue to increase each year due to a growing consumer awareness of nutrition and per capita income increases which result in more food eaten away from home. The majority of seafood is sold in restaurants. Franklin County is one of the leading seafood producing areas in the state. Processors, processing labor and established market channels already exist and should be available to aquaculture producers located in the county. Markets for bait, sport fish or juveniles for enhancement would need to be established.

Market research should be carried out prior to commercial scale production of an aquaculture product. A product must be both raised at a profit and sold in sufficient volume at a profit in order to have value. Market research determines what makes people buy or not buy a product, when they buy it, and how long they continue to buy that same product. A product is then researched to determine what additional features make the product more appealing to potential buyers.

One hypothetical example could be the development of a high quality oyster grown for the luxury market which might be called an "Apalachicola Select." This oyster would be cultured on a well worked leased ground to produce the desired shape and passed through a fattening depuration facility to produce the right taste and quality. The oyster would be cultured in sufficient quantities to service markets year round and have a greater production cost than both oysters harvested from public and leased beds. All these production factors could be estimated in a business plan to final a range of unit costs at various scales of production quantities. Market research would be used to tell if the oyster can be sold and at what price by test marketing the product, surveying potential buyers, and identifying the type of establishment which would offer this oyster on its menu. The research should examine the degree of potential and the amount of promotion which may be required. Research should determine if the oyster can be sold at a price above production cost. Potential orders can be assessed along with frequency of repeat orders, the appearance of the oyster, and consumer reaction to the product. The results of the research would be used to determine the level of production which must be achieved in order for the idea to be profitable or if the idea should be abandoned. Such a study is recommended and could be coordinated through ANES.

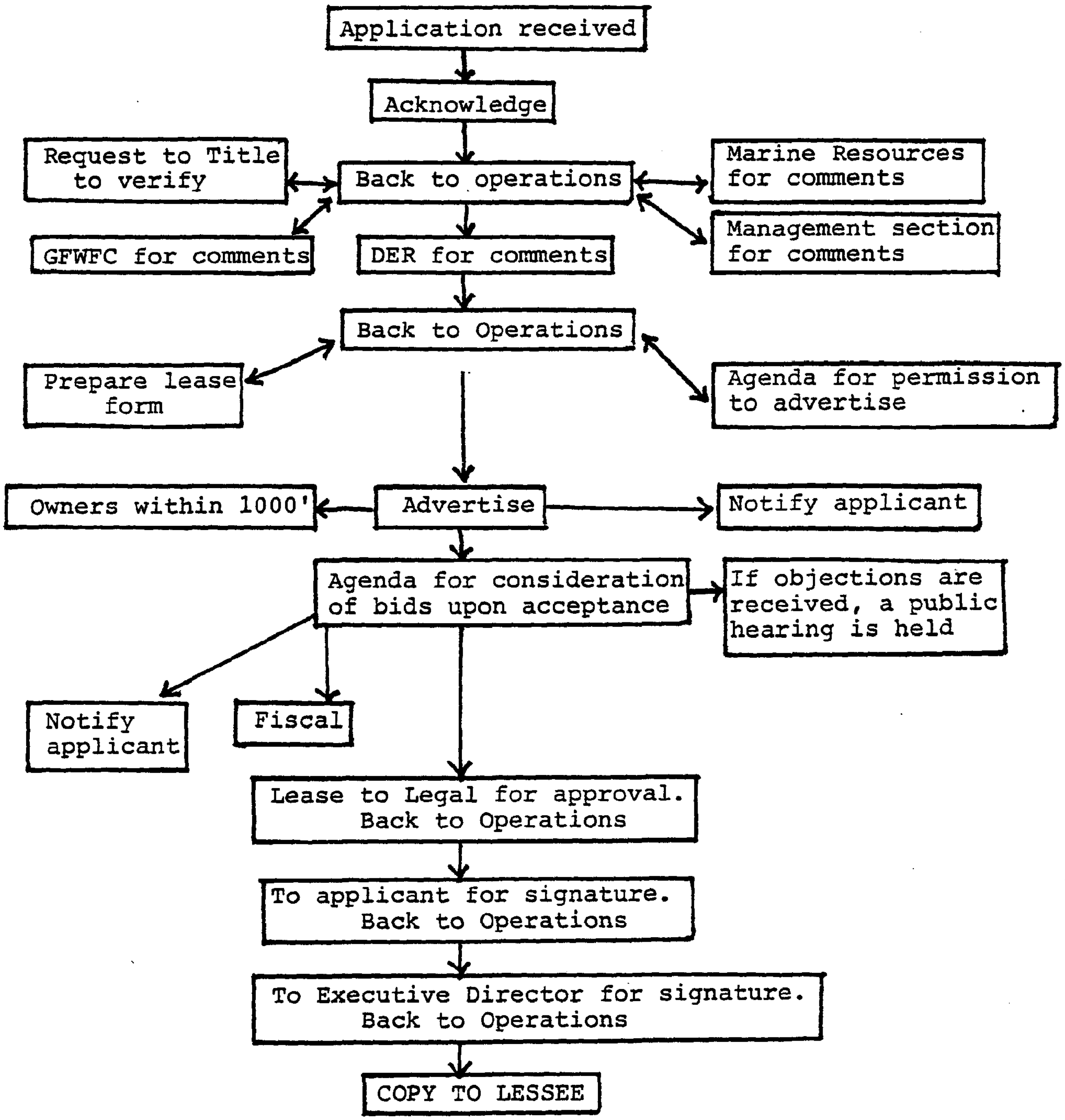

FIGURE 10
AQUACULTURE LEASES

Source: DNR

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Appendix A

OYSTER CALCULATIONS

A. 1 bushel = 62 lbs. = 240 standard oysters = 20 doz. oysters
8.75 lbs. = 1 gallon shucked oyster meat
1.2 bags or bushels = 1 gal. or 7.29 lbs. meat = 1 bushel

B. DNR Reef Construction:
5500 bu/ac = 253.5 cu. yd./ac. oyster shell
Evenly spread this will be a depth of 1.89 inches

C. Oyster Production Estimates:

An ideal oyster growing space is 16 sq. inches
1 acre = 43,560 sq. ft. = 6,272,640 sq. inches
= 6,272,640 ÷ 16
= 392,040 oysters can be grown on 1 acre
= 392,040 - [(25%)(392,040)] mortality
= 294,030 oysters
= 1225 bushels

Thus, approximately 1200 bu/ac/yr can ideally be bottom cultured on a well managed lease. Under optimum conditions, a standard oyster can be produced from spat in 39 weeks.

D. Depth/thickness of shell planted = $\left(\frac{\#cu/yds}{ac}\right)\left(\frac{36\ in}{yd}\right)\left(\frac{acre}{4840\ sq\ yd}\right)$

i.e. $\left(\frac{253.5\ cu\ yd}{acre}\right)\left(\frac{36\ in}{yd}\right)\left(\frac{acre}{4040\ sq\ yd}\right) = 1.89$ inches

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Appendix B

MANUAL OF OPERATIONS

SHELLFISH LEASES

(I) Lease Information

Section 370.16, Florida Statutes, provides that certain water bottoms of the State may be leased for the purpose of growing shellfish.

Anyone may apply to the Division of Marine Resources for a shellfish lease on an application form supplied by the Division. The following procedures are required:

A. Date of Application.
B. Applicant's name, address, telephone number and signature.
C. The name and address of the riparian upland property owner(s).
D. A survey plat and legal description shall be attached *(see note).
E. The proposed lease site shall be permanently staked by the surveyor.

*NOTE: PRIOR TO SURVEY

1. The applicant shall insure the site is, in fact, state land and there are no natural oyster or clam beds thereon or other encumbrances to prevent its leasing.
2. The applicant shall check with the local Tax Assessor to obtain land ownership and riparian owner information.
3. The applicant shall check with the local Florida Marine Patrol District office to insure the site is in an approved or conditionally approved shellfish harvesting area.
4. The applicant shall request that the Bureau have the site inspected to determine if it is leasable. The applicant may accompany the inspector.

Upon receipt of the application, the Division of Marine Resources' Bureau Personnel shall:

A. Sign and date the application.
B. Set up an application file.
C. Using the survey plat and legal description, to insure that the proposed lease site is an approved or conditionally approved shellfish harvesting area.
D. Using the survey plat and legal description, check existing leases to insure the proposed site does not conflict with existing leases.
E. Using the survey plat, legal description, and application, check with Bureau of State Lands and Bureau of Survey and Mapping to insure the proposed lease site is in fact State property and has no encumberances to prevent it from being leased for shellfish cultivation.

Source: DNR

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F. Using the survey plat and legal description, place a legal advertisement once a week for 4 weeks containing the description of the proposed lease in a newspaper of general circulation in the county where the proposed lease is located to notify the public that an application for a shellfish lease has been filed and that objections must be filed within 30 days after last publication to the Division of Marine Resources.

G. Mail a certified returned receipt requested, lease application notification to the riparian owner(s).

H. After items A-G are satisfactorily completed, insure the applicant has posted signs on the corners of the proposed lease.

I. Arrange for a final inspection to insure the area previously inspected and surveyed are the same and are leasable.

J. If riparian owner gives his consent in writing or if the state is riparian owner then no advertising is necessary.

(II) <u>Documentation</u>

The Bureau Personnel shall prepare an original and three copies of a shellfish lease contract between the State of Florida Department of Natural Resources and the applicant.

Upon approval, the original contract and the three copies shall be mailed to the applicant for his signature and the entire current year's lease rent. Upon receipt of the signed contract and rent, the original contract and 3 copies shall be signed by the Executive Director of the Department of Natural Resources. One signed copy of the contract shall be returned to the lessee. The original copy of the contract and a copy of the survey plat shall be filed in the official oyster lease file in the office of the Bureau. The remaining two copies of the contract and survey plat shall be forwarded to the Bureau of State Lands and the Division of Law Enforcement.

(III) <u>Lease Rent</u>

A. Notice. All leases have an annual lease rental which shall be paid in advance. Rent for all leases shall be $5.00 per acre or fraction of an acre per calendar year. Rent is due on or before January 1 each year. Notice of lease rental shall be sent by regular mail no later than December 10. Failure to pay rent by January 30 subjects the lessee to a ten percent penalty rent. A second and final lease rental notice shall be mailed on or about February 1 by registered mail return receipt requested to lessees not having paid their rent. Failure to pay rent by March 5 subjects the lease to cancellation.

B. Receipt and Recording of Lease Rental Monies. The recapitulation sheet, rental notice, and other correspondence pertaining thereto shall be forwarded to the Bureau. A copy of the recapitulation sheet shall also be forwarded to the Bureau of Fiscal Services.

The Bureau of Fiscal Services shall mail to the Bureau a fiscal office daily recapitulation sheet to compare with Bureau and Cashier lease records. Copies of the Fiscal and Cashier recapitulation records shall be maintained together in the files in the Bureau.

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C. Lease Records.

1. Shellfish Administration.

A. Copies of all lease correspondence, transfers, paid lease rental notices, and other pertinent data shall be filed in the official individual lease file in the office of the Bureau.

B. All financial and ownership information shall be recorded on individual ledger sheets by lease number in the official lease record book. The ledger sheets shall also contain the name and address of the lessee.

C. All leases shall be cross filed on 3" X 5" cards in numerical order, by lessee's name in alphabetical order, and by county. The cards shall contain the number of the lease, the name and address of the lessee, the acreage, and date issued for easy reference.

D. The lease number, lease stakes and signs, lease ledger sheet, lease files, and cross reference file shall use identical number for indivudual leases for easy reference.

2. Cashier. The cashier shall maintain records of all lease receipts for easy reference and comparison with the records of the Bureau Personnel.

3. Fiscal. The Bureau of Fiscal Services shall maintain records of rent receipts of the Cashier.

4. Bureau Personnel shall total all recorded lease receipts monthly by comparing the Cashier and fiscal recapitulation sheets, and the daily Shellfish Administration lease receipts ledger sheets. This total shall be recorded on the Monthly Reconcilement of Oyster Lease Rental form and mailed to the Bureau of Fiscal Services and Cashier's office for verification.

5. The Bureau of State Lands shall keep appropriate records of all leases for reference.

(IV) Miscellaneous

A. Numbering. All leases shall be numbered in consecutive numerical order (example 739) as they are executed and leases will retain the original numerical designation followed by letters for each portion (i.e. 739A, 739B, etc.) for easy reference.

If a lease is cancelled for failure to pay rent and resold to the highest bidder, the lease will retain its numerical (and letter) designation.

B. Transfer. A lease is inheritable and transferable in whole or in part. A change in ownership of a lease is invalid and will not be recognized by the Department of Natural Resources unless given prior notice of the change so that accurate records may be maintained. The Department of Natural Resources places the responsibility of a lease on the lessee of record.

A lease is inheritable, in whole or part, at any time without a transfer fee being required. The ledgers of the official record book and the individual lease file will be changed to reflect the change in ownership upon receipt of the Judge's order, notarized copy of a will, or other documentation approved by the Department of Natural Resources' legal staff.

No lease or part of a lease may be transferred by sale or barter until the lease has been in existence at least two years and cultivated according to Section 370.16(4)(b), F.S. A lease cannot be transferred by sale or barter without the express written permission of the Division of Marine Resources and the transferee paying a $50 transfer fee.. The receipt and recording of transfer fees shall be done as lease rental receipts.

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C. Inspections. All leases shall be inspected at least annually to check compliance with Florida law. A copy of the inspectors report shall be placed in the official individual lease file.

D. Notification. The Florida Marine Patrol and Bureau of State Lands shall be notified of all cases of lease transfer, subdivision, reduction of acreage or other lease status changes.

(V) Lease Cancellations

A lease may be cancelled in two ways by the Executive Director of the Department of Natural Resources. Records of cancelled leases shall be retained as mentioned above. Lessees shall be notified by certified mail of all cancellation and of his rights to a Section 120 Administrative Hearing.

A. Cancellation due to lack of cultivation according to standards found in Section 370.16(4)(b), F.S. Each lease is inspected annually for cultivation progress by inspection of the lease bottom by tonging, dragging a chain, wading, etc. The lessee is given notice by certified mail to enable him to comment why the lease should not be cancelled. The Executive Director may cancel the lease in 30 days if there are no comments nor requests for and administrative hearing are received, or if the comments received by mail or at an administrative hearing do not justify keeping the lease active.

B. Cancellation for non-payment of rent. By March 5th of each year a certified letter is mailed to the lessee advising him of the cancellation. Leases cancelled for non-payment of rent are to be sold to the highest bidder. The lease to be sold must be advertised by lease number and description once in a newspaper serving the county in which the lease is located at least 60 days prior to the sale. The advertisement shall contain an invitation to interested parties to contact the Division of Marine Resources for lease specifications.

The bid specifications contain the lease number, description, bidding information, bid opening date, and itemized minimum acceptable bid price for the lease. The minimum price includes the rental due at $5.00 per acre plus penalty, certified mail expenses, and advertising expenses. All monies over and above the rental due and expenses to advertise, etc., shall be paid to the lessee forfeiting his rights herein.

The sealed bids shall be opened on the date and time specified in the bid specifications. The high bidder shall be notified. If he does not mail in the bid amount due within a specified period of time the next highest bidder will be notified and so on.

When the high bidder submits the bid amount, the monies received will be handled like regular rent receipts (see above). A new lease contract shall be completed and signed like newly issued leases contracts. The same lease number will be used.

C. The Florida Marine Patrol and Bureau of State Lands shall be notified of all lease cancellations.

Appendix C

3.17 AQUACULTURE LEASES

Applications for aquaculture leases must include the following:

1. Name and address of applicant;
2. Legal description and acreage of the parcel sought for leasing;
3. Two prints of a survey prepared by a person properly licensed by the Florida State Board of Land Surveyors or an agent of the Federal Government acceptable to the DNR;
4. Description of the aquaculture activities to be conducted and an assessment of the ability of the applicant to conduct such activities;
5. Statement evidencing that the lease is in the public interest;
6. Names and addresses, as they appear on the latest county tax assessment roll, of each owner of riparian uplands within one thousand feet of the parcel sought, certified by the county appraiser;
7. Statement of the impact of the proposed activities on the environment of the area.

If the DNR decides to lease the parcel sought, the lease will be accomplished through competitive bidding. The DNR will cause notice of the lease to be published once a week for four consecutive weeks in a newspaper in the county containing the parcel.

The DNR will not approve an aquaculture lease if it receives, within thirty days of the first publication of notice of lease, a resolution of objection from the county commissioners of the county containing the parcel sought.

Aquaculture leases may not exceed ten years in duration. The annual lease fee may either be a fixed fee or a basic fee plus royalties based upon the productivity of the aquaculture. The terms of the lease will also include the disposition of all improvements and plant and animal life upon termination or cancellation of the lease. The applicant must post a surety bond.

Failure to perform the aquaculture activities for which the lease was granted constitutes grounds for cancellation of the lease.